The Railway and Locomotive Historical Society

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The Norris Locomotives

By P. C. DEWHURST

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The Railway and Locomotive Historical Society,
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Between the years 1831 and 1868, in this country, the Norris locomotive was equally famous with that of Baldwin, Rogers and the other builders. By 1861 or 1862, they had probably built more locomotives than any other builder and by 1868, when the plant closed its doors, it had probably completed around 1500 locomotives. Their product went to all parts of this country and to other countries as well.

Much could be written about the members of the Norris family that guided the destinies of this enterprise but it is not possible to do so in this publication. Sidelights on their opinion will be found in the letters that still exist when it comes to discussing the relative merits of the other builders. William Norris never forgave the Western R. R. for ordering those Winans locomotives. It has remained for our member, Mr. P. C. Dewhurst to assemble this history of the Norris locomotive and present it to our membership. It has required infinite time and patience and has had to be accomplished, at one time, some distance from source material.

Mr. Dewhurst is an English-trained locomotive engineer and has been in charge of the mechanical department of railways abroad, particularly in the West Indies and South America. In his capacity of Chief Mechanical Engineer (our Sup't. of Motive Power) he has had an opportunity of studying the performance of the locomotive. He has been a contributor on subjects covering the technical and historical aspects of locomotive design on English and overseas railways. We hope that our members will enjoy this interesting study on the locomotives of one of our pioneer locomotive builders.

The "Norris" Locomotive—Its Origins and Vogue in America

By P. C. Dewhurst, M.I.C.E., M.I.Mech.E.

PART I

EXPLANATORY FOREWORD

There has always existed considerable uncertainty regarding the early locomotives constructed by the well-known firm of Norris Bros. of Philadelphia, particularly concerning those of the pattern generally known as the "George Washington" and especially as to what this latter engine really accomplished at its famous hill-climbing feats in July 1836 and "how it was done," doubts having existed both in the U. S. A. and in England; whilst doubts have also existed in England as to what the engines exported by the Norris firm to that country really accomplished there, and in the U. S. A. as to what was the real cause of the cessation of purchases of such engines in England. Further than this there has been controversy in Europe as to what extent the Norris original designs —and even more, the actual work of the Norris Bros. in Austria—influenced locomotive development on the continent of Europe.

The evolution of the "Norris" locomotive—the classic 4-2-0 type engine is specifically referred to—was an important phase of locomotive design, whilst additionally the export trade built up therefrom was a major accomplishment for the epoch in which it occurred; and although the influence of the pattern in England was entirely transient, yet on the European continent, particularly in Austria and Germany and to some extent in Belgium, Italy and Switzerland, the influence of the Norris general design and even some of its constructional features, leavened locomotive practice in those countries for a number of years.

The author having in recent years obtained access to early contemporary documents bearing directly on the matter of the use of Norris locomotives in England, found that when combined with other reliable data in his possession and further assisted by information very readily furnished—up till the outbreak of war—from both sides of the Atlantic, he could give a reasonably accurate picture. Believing the subject one of typical interest to the Members of the R. & L. Hist. Society, he presents the results of his researches, in respect to the U. S. A., to its members. That portion of the subject particularly pertaining to England was presented before the Newcomen Society in London in considerable detail in 1947.

It was originally intended to treat somewhat superficially of the evolution of the Norris type in the U. S. A., concentrating principally upon the post—1836 4-2-0 and the earliest 4-4-0 types. Nevertheless, the many apparent inconsistencies in descriptions and illustrations of them persuaded the author that considerable amplification of both these aspects might be acceptable and perhaps furnish a base for consideration —perhaps even controversy—amongst our Members, out of which a final solution may emerge.

In order to lighten the text, references to published books, articles in periodicals etc., are related by number to the corresponding item in the list of authorities given as Appendix 1; in which are included Periodicals and Institution Proceedings. Further, there are cases where the only known illustration is a published reproduction of which the original is no longer available and others in which a reproduction has already appeared in a publication which is fairly easy of access. Such reproductions in books and periodicals are therefore indicated by R. I. (reference illustrations)—1, R. I.—2 etc. and the corresponding original publication cited in Appendix 2.

An extended notice of individual founders and other members of the firm is not given, being outside the scope of this account, nor is this necessary, because an excellent account of same appeared as recently as 1940 (49) which has the added value of giving 'in extenso' the long and detailed account entitled "A Visit to the Norris Locomotive Works" 1855 (20), the latter article being really a write-up based upon information evidently supplied to the periodical by the Norris Works people themselves. Sufficient attention must however be directed to the Norris early organisation and its productions leading up to the "George Washington" to indicate the technical atmosphere in which the Norris firm worked at the time of the latter's production.

It is in the "inspired" article of 1855 that there appears the first suggestion—as far as the author can discover—of opposition by the British locomotive manufacturers of the time to the importation of locomotives into England. This matter of the supposed procurement of a Government embargo will be fully dealt with in a separate account, it merely being mentioned here that the 1855 account is in error in that respect.

Some references will be made to Sinclair's "Development of the Locomotive," New York 1907, a work in which American locomotive history is unfortunately treated in a remarkably disjointed fashion—it being in great part an account of the doings of the early U. S. A. locomotive designers as individuals—but which is nevertheless the only comprehensive account of U. S. locomotive development treated in any detail; and, again, unfortunately, many of the references made to it here are to signalize errors. See also Sinclair's prior articles of 1903-5 (34). One capital error is an illustration of a 4-2-0 engine entitled "Early Norris" having outside frames and with the driving wheels *behind* the firebox, the title inviting the misleading supposition that it might represent either the "G.W." or one of its predecessors; the drawing (R. I. 1) however clearly represents an engine by H. R. Dunham & Co.—a line-drawing of the same engine is given by E. P. Eastwick Junr. in "Railway Age Gazette" of 22/4/92 as "by Dunham & Co. 1837"—and in any case it is so close a copy of the contemporary Baldwin 4-2-0 as to have no bearing on the form of the "G.W."; it could not, for instance, have had such a proportion of weight upon the driving wheels as had the "G.W."

An excellent general account of the Norris locomotives in U. S. A., particularly of the later types and patterns of locomotives built by the

firm—and comprising many illustrations—by C. H. Caruthers, appeared in the "Railroad Age Gazette," New York for 6th, 13th and 20th of August 1909; and information concerning some of the early Norris engines has been taken or checked therefrom for this account. Sinclair's book above-mentioned also has many references to later-built locomotives by Norris.

PRELIMINARY AS TO THE FIRM AND SOME ACCOUNT OF NORRIS PRE-"GEORGE WASHINGTON" LOCOMOTIVES

The origin and early days of the firm may be briefly set out, together with some necessary mention of its pre-"George Washington" locomotives, as follows:

In 1830 Colonel S. H. Long of the U. S. Army (Engineers) interested himself in locomotives, taking out patents in connection therewith in 1832 and 1833. He came in contact with William Norris, and afterwards formed an association with him and others during 1833, but after only a short period the group was dissolved and by about the end of 1834 Long himself had left the firm—and locomotive-building also. Nevertheless during the relatively short period 1831-4, Long contrived to design and construct a number of remarkable locomotives, about which many conflicting accounts have been current even from early days.

It appears that some time during Long's operations he became assisted financially by a private group including W. Norris—who was by occupation a dry-goods merchant—and later on, about the end of 1833, a company was formed under the title of "The American Steam Carriage Co." including Long, Norris, and three others—Norris being Secretary—although whether a formal statutory Company was constituted is not certain. This group took over from Long the afterwards well-known Norris Shops on Bush Hill, Philadelphia. The concern seems, however, to have been quickly dissolved because from some time in 1834 the firm appears as "William Norris." The exact date when Long became disassociated from Norris is likewise not quite certain, because whilst a locomotive turned out in May 1834 for the Phil. Norr. & Germantown R. R. and one in 1835 for the Boston & Providence R. R. (which latter, however, may have been the engine by Long of 1833-4 previously mentioned as later upon that line) appear in a Government report of 1838 (5) as by "Wm. Norris," another engine built by the firm in 1835 for the Phil. & Col. R. R. (Alleghany Portage section) is shown as built by "Long & Norris." It seems however that the association of Norris and Long only lasted for about a year after the group took over the Bush Hill Shops.

Long's first locomotive, built at the Phoenix Foundry, Kensington (now part of Philadelphia) was tried upon the Newcastle & Frenchtown R. R. on June 4th, 1831, being, however, a failure due to insufficient grate and heating surface of the boiler. It is inferred from J. Harrison, 1871, (25)—referred to later—to have somewhat resembled the locomotives then made in England, but the boiler was entirely different; the engine weighed about 3½ tons. It was removed from the railway shortly

afterwards, a new boiler was made for it and further trials were made in 1832 and 1833 apparently without success, although the final boiler—which may have been in accord with Long's subsequent patent of 1833—was apparently not lacking in steaming capacity. It later seems to have made a trip upon the Philadelphia & Columbia R. R., where it signalized itself by first running out of fuel and then of water. Hodge, 1840, (8) says Long's first boiler "was shaped in front like the bows of a boat—it had two return flues." The locomotive was evidently discarded after the trials of 1832-3; portions very likely being used up by Long in later engines.

Long's next locomotive seems to have been completed in the latter half of 1832, being named "Green Hawk," and it was tried on the Phil. & Col. R. R., being followed in June 1833 by an engine "Black Hawk" and by another the name of which is now unknown. No further record seems available of the first and last (but see below), whilst "Black Hawk" after being tried also upon the Philadelphia, Norristown & Germantown R. R. eventually went to the Boston & Providence R. R. Harrison says that it was on four wheels and that the boiler burnt anthracite coal, that it had "twin" barrels which also formed the top portion of the firebox and that for the purpose of creating natural draft a very long chimney—reaching 20 feet from rails—arranged to lower for passing under bridges, was provided. He also describes the engine as having inside cylinders with the crank-axle in three parts arranged in such manner that springs were not admissible over the driving axle; the valve-gear was of a "cam" type then in favor on river steamers. Minute particulars of "Black Hawk" are given by Harrison in his book, whilst a drawing of the boiler appears in the account above-mentioned of the productions of the Norris Works by Caruthers (37). Whatever was the final ownership of "Black Hawk," it can have done but little work, as from the Norris-inspired account of 1855—referred to above—it had then been "resting" 21 years, i.e. from 1834.

Another Long locomotive appeared, in the spring of 1833, upon the Phil. Norr. & Germantown R. R. and this seems to have been a tank engine; it had Long's patented boiler including the twin boiler-barrels. There were four wheels, the driving being about 4 ft. 6 in. and the other pair about 3 ft. in diameter, it weighed 4½ tons and is believed to have had inside cylinders and "cam" cut-off. The railroad took over the engine, but soon disposed of it; it was named—at least at some period—"Pennsylvania," and went to the Tuscumbia, Courtland & Decatur R. R., Alabama, in February 1835.

In February 1834 another Long locomotive appeared, this time upon the Boston & Worcester R. R., but its trials were evidently not satisfactory enough for the railroad to complete its purchase and no record of its subsequent career is available. It is possible that this engine was one of those previously on the Phil. & Col. R. R. mentioned above; it is also possible that with some others of the locomotives previously mentioned it is a case of "re-appearance in a new character"—and a new name!

Having arrived at the time when Long probably left the firm, it must be said that the foregoing account is based upon the best of the available contemporary evidence—some of it kindly communicated by Mr. Thomas Norrell, who, however, is in no way responsible for the solutions put forward—and it is necessary to record two other accounts, of medium early date, which are in discrepancy between themselves—a characteristic of this subject—and differ somewhat from that given above.

One version states that in 1834 Long & Norris constructed three locomotives, to burn anthracite coal, for the Boston & Providence R. R., but the line (or its enginemen) preferred wood and thus the engines were laid aside or at any rate only used for ballasting and odd work. This is the version in D. K. Clark 1855 (21) and H. L. Norris 1887 (29); Harrison also states "other locomotives, mainly after the design of 'Black Hawk,' were built in 1834 but were not greatly successful." The other version, Colburn 1871 (26) and Sinclair 1907 (36), however, states that only one locomotive was built in 1834; Colburn quoting "from the books of the firm, Richard Norris & Son"—which was the title of the firm at the time he wrote. These three engines do not appear in the U. S. Govt. return of locomotives in use in 1838 (5) nor were they recorded by Von Gerstner who checked up most locomotives existing in U. S. at that time (7), nor are they mentioned in the writeup of 1855 (in which is an acknowledgement to Colburn, then Editor of the "Railroad Advocate" for data supplied). Nevertheless they seems to correspond—but for the difference in date—to "Green Hawk," "Black Hawk" and another "name unknown" previously referred to, in which case all three engines and not merely "Black Hawk" went to the Boston & Providence R. R., and in this regard mention should be made of a Norris engine "Lincoln" later appearing in the inventory of the Boston, Hartford & Erie R. R. to whom it must have come via one of that railroad's predecessors. As the three particular engines are said to have been out of favor on the B. & P. for the reason given, it is possible that being little used at the time of the 1838 return and of Von Gerstner's visit, they were not included in the lists furnished to those authorities.

In May 1834 one locomotive, "Star" for the Phil. Norr. & Germantown R. R. was completed and the existence of this locomotive is not in question being no doubt the one locomotive Colburn and Sinclair had in mind for that year; it duly appears in the 1838 return. From the same return we have record of two Norris locomotives of 1835, they being engines to the Boston & Providence and Philadelphia & Columbia railroads, named "Philadelphia" and "Benjamin Franklin" respectively.

There was also the "William Penn," delivered to the Phil. & Col. R. R. on October 10th, 1835; it can be traced in the railway records, but does not appear in the Govt. return of 1838. In this regard it is significant that in a railway report for the year ending Oct. 31st, 1837, it is stated that four engines, among them the "Wm. Penn," had not been used for the past year having been built before recent improvements, "extensive changes not recommended;" no doubt it was soon

disposed of to another railway. Incidentally we here have a surprising indication of the rapidity with which a locomotive could become out-of-date at this period. As originally built the "Wm. Penn" might have been possibly considered as an advance-prototype of the "George Washington" pattern but the tenor of the report plus the fact that the "G.W." would not then have been a new departure in July 1836 preclude the idea. The engine is mentioned here because it was rebuilt by the Norris firm in 1865 as a 4-2-0 of approximately "Washington County Farmer" pattern (see below)—except the boiler—and lasted until 1898 when a photograph was taken of it (R. I. 2). What its original design was does not now appear, and the writer would suggest that a very interesting field of research lies in these early Long-Norris designs whose elucidation would produce information of great value to locomotive history.

In the following year, 1836, appeared the afterwards well-known locomotive "George Washington"—"what's in a name?"—which will be fully dealt with further on, and it would seem that only one engine had been completed in that year prior to the "G.W." of July, and one other subsequently, the former the "Robert Morris," and the latter the "James Madison," all three for the Phil. & Columbia R. R., because eight locomotives are stated (by Colburn, Sinclair and others) to have been built in 1836—and which is confirmed by the previously-mentioned Govt. document—of which the three above-mentioned appear to have been of the "G.W." pattern and five of what will be referred to in this Paper as the "true" Norris, the first of which was the "Washington County Farmer," likewise dealt with fully further on. Note that it is *just* possible the "Benj. Franklin" and "Wm. Penn" were also of "G.W." pattern.

Here it should be stated that the titles of the firm from whom W. Norris took over during 1834 were: "William Norris" 1834 to 1841; "William Norris & Co." 1841 to 1844; "Norris-Brothers—Norris Locomotive Works" 1844 to 1852; after which the title changed to "Richard Norris & Son" etc. until their final year 1869; the firm started other locomotive-building works in U. S. A. with which we here have no concern, see (49). From 1841 William Norris formed a partnership with his brother Richard, but in 1844 William and another brother Octavius went to Austria and opened locomotive building Shops at Wien (Vienna). Most subsequent references cite this move as being by special invitation of the Austrian Government and that they took charge of the Govt. Shops; but this—like so much else, as will be seen—seems inadmissible because the government and other railway Workshops in Wien during that period were in charge of other engineers than the Norris brothers. In any case W. Norris was back in the U. S. A. by 1848 when he became Engineer of a division of the Panama Rly. and disappears from the locomotive scene. Contemporary references to the termination of the Wien venture speak of the honours and presents from the Emperors of Austria, France and Russia with which the termination of their period in Austria was signalized; it was also stated that whilst the brothers were in Austria their system and improvements were thoroughly imbued by all the Departments of the Government Work-

shops. Nevertheless the facts of the history of locomotive building in Europe do not support the apparent success; on the contrary it is clear upon analysis that the Austrian locomotive-building establishments which had sprung up shortly before the opening of the Norris Works in Austria had already taken examples of the Norris type previously exported as a basis to which they added improvements (and in some cases the contrary) and thus submerged the Norris concern by home production; in the words of their own later locomotive engineering commentators, they "imitated the Norris engines"—and to such good purpose as to effectually put the Austrian branch out of business. Harrison's dictum "W. Norris commenced the building of locomotives at Vienna, but with no very great success" seems to accurately sum up the matter.

From 1845 under the title "Norris Brothers" the Philadelphia firm consisted of Richard Norris, who seems to have been the principal; and by 1846 a younger brother Septimus Norris, who was certainly responsible for much of the technical progress of the firm, had become partner. There were important changes in the constructional features of the engines between 1843 and 1847 which suggest that when William and Octavius went to Austria leaving Richard and Septimus, there was a considerable change in designing influence on the Philadelphia productions.

No further particulars, nor any drawings whatever, of the pre-"George Washington" locomotives have been developed by the author, but drawings of Long's vertical boiler and horizontal (double-barrel) boiler for locomotives appear in Caruthers 1909 (37) and the design of the latter boiler supports the view that Long's ideas tended toward the complicated where a more simple device would have served the purpose.

THE "GEORGE WASHINGTON": WHAT WAS IT AND WHO DESIGNED IT?

It has been generally supposed, but not by all locomotive engineers, that the "George Washington" was of the same design as the well-known—referred to here as the "true"—Norris 4-2-0 pattern, this being fostered by a sequence of descriptions to this effect running into quite recent years; publications of the Norris firm itself also helping this misapprehension. Analysing various contemporary, or relatively contemporary, authorities it must inevitably be concluded that the "George Washington" was *not* of the same pattern as the true Norris.

In the inspired article of 1855 (20) the following statement appears: ". . . Another improvement was effected here, in October 1836, by making the connections all outside the frame. The 'Washington County Farmer,' the first engine on this principle, was successfully worked on the inclined plane, in that month. . . . The outside connection was first successfully adopted at these works, and was, for many years, the leading feature of the Norris engines. Most of the other builders, until 1840, or 1842, used either the 'full,' or 'half-crank' connection; upon neither of which plans could the same capacity of engine, or the same compactness and simplicity of construction be obtained, as with the outside connection."

It is clear the reference "outside connection" can refer to nothing else than the main driving gear because in the "true" Norris that *is* the only part outside the main frames; hence the previous engines must have had the drive *inside* the frames. Strong support to this view, and that the "Washington County Farmer" was the first engine so built, is the fact that a special trial—and report of same—was considered necessary by Norris. (Vide: trial No. 3). If the production of the same pattern had continued right along from the "George Washington," a third trial would have been unnecessary, as obviously it would have been preferable to "let well alone" rather than run the evident risk of a further trial producing less fortunate results.

It is just possible to read into the wording of the 1855 article that the reference was to a change from an inside valve-gear outside-cylinder engine to an engine having both valve-gear and cylinder connections outside, vide "connections all outside the frame" in the article, but this is considered untenable in view of the fact that no example of such a Norris locomotive is recorded anywhere and the firm in 1855 would not have emphasized so forcibly a change which, if it had been done by them, was only ephemeral.

Very important corroboration now comes into the picture. In 1838 U. S. Congress directed a record to be taken up of the steam boilers, including locomotives, then in use in the Country (5). One table in this document schedules the locomotives of the Alleghany Portage Rly. in a very particular manner, grouping the locomotive "G.W.", ("G.W." was built for the Philadelphia & Columbia R. R. but by 1838 had been transferred to the Alleghany Portage line) together with other locomotives. See Appendix 8. It is clear that, notwithstanding some incorrectness in the placing of the brackets by the compositor, the original manuscript made a definite division between the engines having short and long pitmans (i.e. connecting-rods) etc., and that the "G.W." falls into the group classified as "these engines have *inside* connections, and *short* pitmans, producing much friction. Iron truck frames—an improvement"; whilst other engines (which we know were *true* Norris W. C. F. pattern) are specifically noted. "Improvements are *outside* connexions, *long* pitman, with wrist *outside* of drivers." John Kern was somewhat acquainted with mechanical engineering matters as the same document shows he was interested enough in the technical aspect to engage in correspondence with H. R. Campbell and other mechanical engineers on steam engines etc.; there is thus no doubt that the "G.W." was not of the true Norris pattern. The solution of the problem as to what it was really like will now be attempted, but it seems desirable first to mention certain more or less contemporary accounts which at first sight appear to suggest it was like a true Norris.

J. Harrison, a contemporary rival locomotive designer who had previously been with the Norris firm—and hence should be a first-class witness—in his book of 1871 (25) deals with many points connected with the problem of the "George Washington." He says:

"On the retirement of Colonel Long, William Norris, a gentleman then with no acknowledged pretensions as a mechanic or engineer, brought other skill to his assistance, and after several not very successful efforts with engines of a design more like those that had succeeded of other makers, brought out an engine, in 1836, called the 'George Washington,' the success of which . . ." "The 'George Washington' was a six-wheel engine with outside cylinders, having one pair of driving wheels, 4 ft. in diameter, forward of the firebox, with vibrating truck, for turning curves, in front. This engine weighed somewhat over fourteen thousand pounds, and a large proportion of the whole weight rested on the single pair of driving wheels. This locomotive, when put upon the Columbia road (now Pennsylvania Central), did apparently, the impossible feat of running up the old inclined plane at Peter's Island, 2,800 feet long, with a rise of one foot in fourteen, drawing a load of more than nineteen thousand pounds above the weight of the engine, and this, too, at a speed of fifteen miles per hour. This was no doubt impossible, if the simple elements of the calculation are only considered. But there was a point in this experiment, well known to experts at the time, which *did* make it possible, even by calculation; and this point consisted in the amount of extra weight that was thrown upon the drivers by the action of the draft link connecting the tender with the engine—the result being that about *all* the weight of the locomotive rested upon the drivers, less the weight of the truck frame and wheels in front. This most extraordinary feat, a writer on the subject says, 'took the engineering world by storm, and was hardly credited'." "The 'George Washington' . . . the fame this engine earned led to large orders in the U. S. and several locomotives of like character were ordered for England and for Germany."

"The Norris engine, as it was at the commencement of 1837, may be described as follows: The boiler was of the dome pattern, known in England as Bury's, and used by that maker in 1830; the framing was of wrought iron. The cylinders were placed outside of, and were fastened to the smokebox as well as to the frame. The engine was supported on one pair of driving wheels, placed forward of the firebox, and on a swivelling four-wheeled truck placed under the smokebox. The centre of the truck being so much in advance of the point of bearing of the leading wheels in the English engines of that day, there was considerably greater weight placed upon the driving wheels in proportion to the whole weight, while it was not unusual to adjust the drawbar so as to throw a portion of the weight of the tender upon the hinder end of the engine when drawing its load. These engines used four eccentrics with latches. Hand levers were used for putting the valve rods into gear when standing. The valve motion was efficient, as the performances of these engines fully attested."

From the foregoing it might appear that the "G.W." *was* of the outside connected pattern; but closer consideration of the Harrison wording leaves room for doubt. In the first of the two paragraphs quoted, dealing with the "G.W.", he mentions "outside cylinders," and comparing with the majority of the locomotives in U. S. A. in 1836, deriving from the English pattern having the cylinders below the smokebox and well inside the wheels, an engine with cylinders at the *side* of the smokebox has "outside" cylinders. That the matter is not settled by the apparently obvious interpretation further appears from the last paragraph beginning "The Norris engine, as it was at the commencement of 1837 . . ." which suggests that Harrison knew something different was required to describe the later engines, and the change of design in the "Washington County Farmer" of Oct. 1836 with its "connections all outside the frame" seems to provide Harrison's actuating motive. Harrison also mentions that "several locomotives of like character were ordered for England . . ." His "like character" and "as it was at the

commencement of 1837" are considered grounds more for concluding that Harrison knew there was a difference between the "G.W." and the 1837 Norris, than the contrary.

It is very necessary here to refer to a supposed design embracing inside frames and inside cylinders—in fact an apocryphal illustration of such an engine was once given by Snowden Bell 1929 but the drawing shown there is merely the R. R. Gazette drawing of 1887 "doctored" to show the connecting-rods inside. It is important to consider this suggestion, if only to demonstrate its mechanical impracticability. Such a design, as will be seen from Snowden Bell's diagram (R. I. 3), predicates the use of cranks just within the wheels, somewhat like—or even of—the Baldwin half-crank style, but with the axle bearings *inside* the cranks; such an engine could have been drawn and actually so constructed, but the transmission of the weight of the engine *through* the cranks is so mechanically unsound that crank breakages would inevitably ensue—it would have been a complete mechanical failure.

Concluding thus that the "George Washington" was inside-connected but outside framed, then it must have been very similar to the then-current engines of various makers but with the driving wheels in front of the firebox; a lay-out like the "Sandusky" by Rogers 1837 (R. I. 4) but with bar frames and different boiler and having—according to Mr. Kern—an iron truck frame; this latter very likely being the germ of the idea of putting all the bearings inside with a bar-pattern main-frame on the "Washington County Farmer" in October 1836—3 months after the "George Washington."

One apparent difficulty regarding the foregoing judgment should be mentioned, it is that the total weight of the "G.W'.' would be very light for an outside framed engine compared with other makers' designs of the period, but if—as is considered probable—the "G.W." had bar framing the discrepancy disappears.

It has therefore been shown (a) that the "G.W." was outside-framed, (b) the driving wheels were in front of the firebox—Harrison, (c) the cylinders were "inside" (i.e. not outside the frames) and (d) there was a four-wheeled bogie in front; thus we have a general picture of a 4-2-0 engine as produced by various U. S. A. firms, but in view of the evident fact that the first true Norris had inside frames of bar pattern the probabilities are that the "G.W." had (outside) bar frames of somewhat similar type. This solution contemplates the particulars given in all contemporary accounts and is supported by considerations of weight distribution; "G.W." carrying 58% of its total weight upon the drivers, whilst the true Norris of classes "C," "B," "A" and "A-extra" had 51%, 62%, 70% and 68% in that order. It will be noted that the smallest of the *true* "Norris" had a lesser proportion of adhesion weight than "G.W.", but Norris' table of dimensions indicates that the "C" class had a very small boiler because not only was it of less diameter than the "G.W." but its weight distribution suggests it had even a smaller firebox than that engine. That the "G.W." resembled the true Norris in many respects can be taken for granted because otherwise the difference between the "G.W." of July 1836 and the

"W.C.F." true 4-2-0 Norris of October the same year would have been so great that the "folk-memory" of the locomotive men of the time would have registered it; also, as above-mentioned, the weight-distribution would not have been applicable to a greatly differing type.

Essays into possible general designs reveal that a combination of the known features and dimensions of the "G.W." with a family ancestorship to the true Norris, in particular adopting the "Bury" type boiler with barrel of same diameter as Norris class B—which carried the same number of tubes (78)—but of lesser length (7 ft.) as in Norris class "C"; is only practicable with the cylinders set in two alternative positions. Hence a schematic diagram, Fig. 1 has been prepared setting out these alternatives.

The only practicable positions for the cylinders with an outside-frame are shown in "A" and "B," "A" being very similar in position, but naturally a lesser distance centre to centre, than in the true Norris, whilst it is just possible to get them in position "B" with an outside frame to the bogie. From the part-plan it will be seen that "A" must include the use of some species of combined crank-axle and wheel-centre, whilst "B" shows the minimum distance practicable from the driving axle centre to the front of the firebox shell; "B-1" shows how the space is limited under the boiler if this latter arrangement be attempted and that it is quite impossible to have inside cylinders closer together in combination with the bogie unless the boiler be lifted a very considerable amount. In this appear the designing difficulties introduced by the bogie compared with the relative facility of a non-bogie design; it is interesting to note that a double-framed engine of a type similar to the Norris could barely be arranged even with alternative "B."

The design meets all the known facts; as will be observed the two alternatives are not combinable and the most probable one is that having the cranks close to the wheels as in that arrangement the proportion of weight upon the driving wheels would be about that attributed to the "G.W." in the 1836 reports, whilst the cylinders sit at practically the same height (but of course closer together) and the bogie-frames fit, as in the "W.C.F." The only tendency in favour of the inner-lower cylinders well "inside" is Kern's remark "short pitmans;" as to this the customary length of connecting-rod in the four-wheeled Stephenson-type locomotives of the 1832-4 period as sent to U. S. A. was 3 ft. 6 in., that of the true Norris about 5 ft. 6 in. (substantiating Kern's pointed distinction), whilst solutions "A" and "B" would have had rods about 4 ft. 6 in. and 4 ft. 1½ in. respectively. With a bogie as a definite component, it will be seen that the "inner-lower" cylinders could only have been closer together if the engine had been inside—(or at least double—) framed and the boiler pitched considerably higher, nor could they have been wider apart because of bogie-wheel clearances; bogie-frames inside the wheels makes any inside cylinders impracticable unless the boiler is placed much higher.

From the weight distribution of "G.W." it is probable the boiler had the small firebox and has been so shown, whilst for purposes of comparison the true Bury form is indicated by dotted lines. Although the

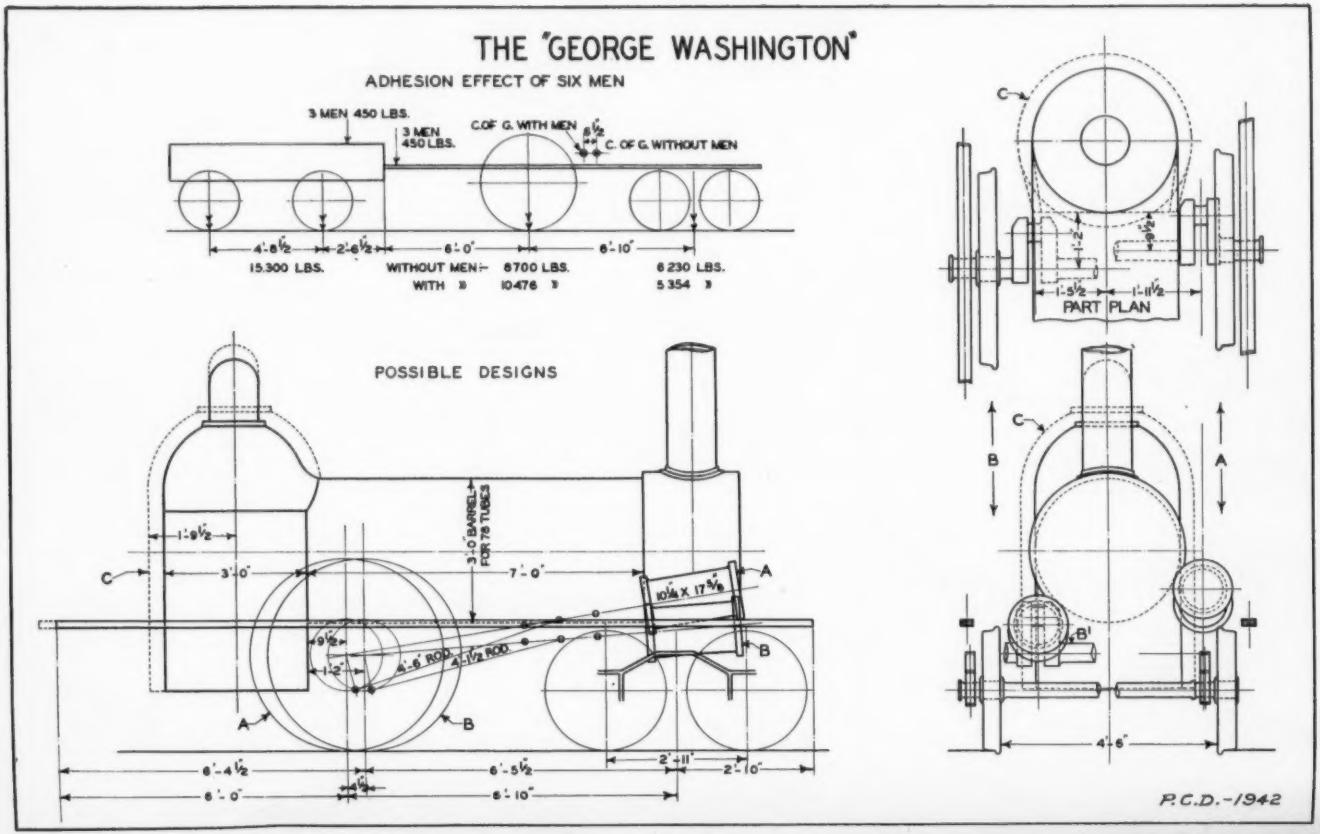
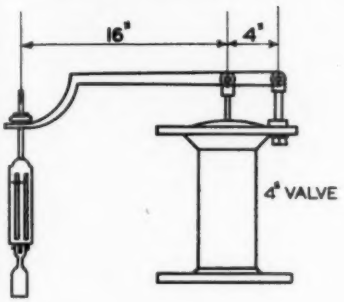

THE "GEORGE WASHINGTON"
ADHESION EFFECT OF SIX MEN
3 MEN 450 LBS.
3 MEN 450 LBS.
C.OF G. WITH MEN
C. OF G. WITHOUT MEN
4'-8½"
2'-6½"
6'-0"
6'-10"
15.300 LBS.
WITHOUT MEN
WITH "
8700 LBS.
10476 "
6230 LBS.
5354 "
POSSIBLE DESIGNS
3'-0 BARREL FOR 78 TUBES
1'-9½"
3'-0"
7'-0"
10¼" X 17⅝"
9½"
1'-2"
4'-6" ROD
4-1½" ROD
6'-4½"
6'-0"
6'-5½"
6'-10"
2'-11"
2'-10"
PART PLAN
1'-5½"
1'-11½"
4'-6"
P.C.D.-1942

Figure 1

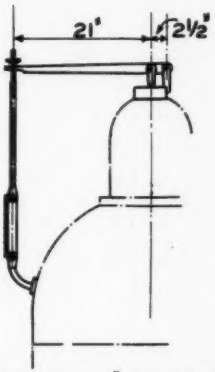
EARLY SAFETY VALVES

HODGE'S SKETCH



PROPORTIONS DERIVED FROM
HODGE'S TEXT. 1840

NORRIS'S ARRANGEMENT



PROPORTIONS AS "WASHINGTON"
CIRCULAR OF 1838

Figure 2

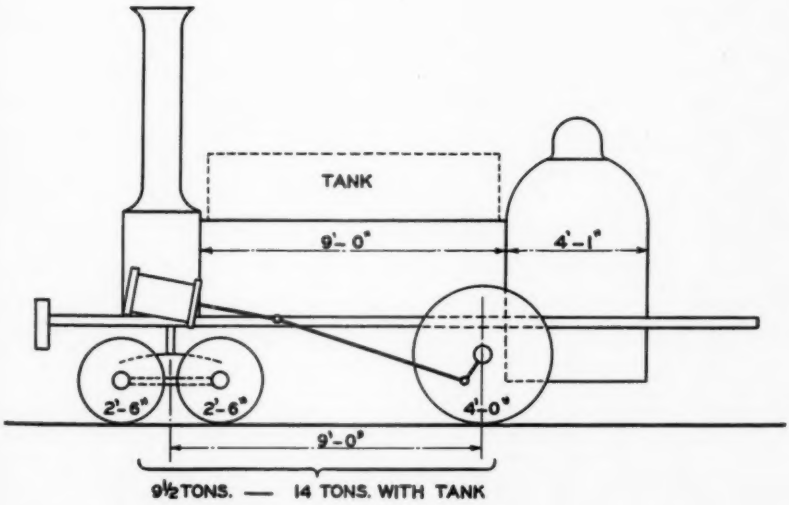


Figure 3

solutions outlined in Fig. 1 can only be classified as "inherent from the available evidence" an engine so constructed would, under the conditions explained further on, have been capable of accomplishing the grade-climbing feats claimed for the "G.W."

There is little difficulty in accounting for the, at first sight, inexplicably ephemeral remembrance of the "George Washington" design. The "Washington County Farmer," appearing only three months later, forming really an improvement on the "G.W." in that whatever the "G.W." could do, the "W.C.F."—assuming the same cylinder and valve volumes, ports and valve-gear plus its advantages over the "G.W." —could have done better, inherited the propaganda-value, and it would obviously have been bad policy to lose that reputation by blazoning the fact that the "W.C.F." and successors were not strictly of the same famous family. Then the appearance in 1838 of the Norris "Circular" (4) in which the exploits of the "G.W." comprise practically the whole subject-matter and having its large plate of a true "W.C.F." Norris named "Washington"—which we can suppose represented any one of the three other compounded ". . . Washington" engines running at that time or the only one actually named "Washington" to the Carrollton R. R. late in 1836—the railway world naturally coupled the account of "G.W." with the plate of "Washington" and so the error was firmly launched on its 100 year career of mistaken identity on what amounted (almost) to reputable documentary evidence!

The question of who really designed the "G.W." is somewhat uncertain—even the designer of the "W.C.F." is not certainly determinable—and it is apposite therefore to consider what P. R. Hodge, who was an engineer and contemporary in the locomotive business in the U. S. A. at the time, says in his book of 1840 (8). He recounts that after Col. Long had "fully satisfied himself and Mr. Norris of his inability to perform the task" [of producing a satisfactory locomotive] and had abandoned the undertaking, Mr. Norris meeting with Mr. F. D. Sanno, "an intelligent and clear-headed mechanic," engaged his services. "Mr. Sanno . . . set to work and made a new boiler; he however used the old cylinders and some other parts and finally turned out a new engine"; going on to recount that this engine successfully ascended the Colombia Inclined plane in July 1836 and that subsequently "under the superintendence of Mr. Sanno success would be attained" etc., Hodge thus makes it appear that the discarded cylinders and parts re-used for "G.W." were those which had been originally applied to the *first* locomotive produced under the direction of Col. Long and so disregarding the fact that there had been a number of other locomotives produced by Norris between the first of Col. Long and the "G.W." On Hodge's large plate of the Norris pseudo—"Victoria" it is stated "laid down and arranged by F. D. Sanno" and this certainly seems good contemporary evidence that that engineer was connected at least with the *true* Norris, because otherwise controversy would have arisen on the publication of Hodge's book.

Further, in the discussion on Colburn's Paper of 1869 (24) Hodge said, "Subsequently Mr. Norris employed Mr. David Sanno, who put a

new boiler to the engine and so remodelled it to take a load up the inclined plane on the Pennsylvania State Road in the year 1835" (Sic. 1836); thus repeating his account of 1840. According to Sinclair 1907 (36) Hodge was an Englishman who had been the Rogers Locomotive Works first locomotive draughtsman—but had made a mess of the "Sandusky" and lost his position!

On the other hand Colburn 1871 (26) says the "G.W." was "designed by Mr. Harrison" and, even more categorically, "Joseph Harrison, who was the original designer of the Norris engine, long made in America," thus leaving no doubt as to his belief at that much later date; yet Harrison had seemingly gone from Norris to Eastwick before the "G.W." was built! J. Harrison, who was the "mechanical" man with the Eastwick firm, seemingly when it commenced in 1835-6 and had previously been two years in the Norris Shops—and therefore also first-rate contemporary evidence—states in his book of 1871 (25) that Wm. Norris having then "little engineering knowledge and no practical skill in engine building . . . brought other skill to his assistance" and this would satisfactorily accommodate both Hodge's and Colburn's statements. Nevertheless Harrison appears amongst the names of the 42 engineers and others who accompanied the second "G.W." trial and it seems probable that he had something to do with the "G.W." whilst Sanno was connected with the "W.C.F."; this is an unsatisfactory conclusion and it is hoped more light can be thrown on the point in U. S. A.

THE "GEORGE WASHINGTON". HOW DID IT ACCOMPLISH ITS FAMOUS FEATS?

We now come to the event which according to early locomotive writers "took the engineering world by storm and was hardly credited"; this first burst upon the world in the "American Railroad Journal" of July 16th, 1836, (1) followed in the issue of July 30th, 1836 (2) by an apparently clinching second event.

It has first to be noted that, contrary to what appears from subsequent references in technical literature, the *second* feat of the "George Washington"—that of July 19th, 1836 (2) when the train was accompanied by a galaxy of witnesses—was the more difficult of the two. There followed a third demonstration, in October, with the locomotive "Washington County Farmer" (3), and for convenience particulars of all three tests are given in Appendix 3. The demonstration took place upon the "Belmont" inclined plane of the Philadelphia & Columbia R. R. old line on Peter's Island near Philadelphia. (R. I. 5).

Analysing the ascents and taking established resistances for gradient, friction etc.—and giving the engine every benefit—it is found that for the first test, 2498 lbs. tractive effort is required. The output of the engine at 60 lbs. steam pressure in the boiler (and taking the R. T. F. at 85%—which may appear high for an engine of such early date, but seems justified by a reference, given further on, to the ample steam passages) being only 1967 lbs., the boiler pressure would need to have been over 76 lbs. per sq. inch to produce the required effort; under which

latter circumstance the adhesion factor A.W./R.T.F. would be just under 3.5, and thus barely sufficient. Analysing the second test the tractive effort required is 3370 lbs., whilst the engine at 80 lbs. boiler pressure would only produce 2623 lbs. and a boiler pressure of almost 103 lbs. would be required to overcome the resistance, the adhesion ratio then becoming 1 to 2.6—an entirely impossible figure; thus for the second test, and taking as low a ratio as would suffice in the case under notice of 3.75, an adhesion weight of 12.638 lbs. would be required.

In the case of the third trial—later on, with the "W.C.F."—the tractive effort required is 3525 lbs. whilst that which this latter engine could produce, at 70 lbs. pressure, is 2460 lbs.; and the boiler pressure would need to have been 100 lbs. to produce the required effort; under which circumstance the adhesion weight required to provide the minimum ratio of 1 to 3.75 would have been 13219 lbs. This figure it should be noted is close to the figure of 12781 lbs. adhesion weight attributed by the Norris firm to the *true* Norris 4-2-0 class "B" engine in their 1841 Circular (10), although the adhesion weight of the "W.C.F.", calculated at 62% of the total weight given for that engine in the trial (the adhesion weight is not given separately), would nominally have been about 11.265 lbs.

In resolving these apparently impossible performances it is evident the secret must lie in both the steam pressure and the adhesion, and it is simple to demonstrate that none of the three climbs could have been accomplished at the boiler pressure stated to have prevailed, whilst the second test, particularly as to adhesion, is entirely the more dubious of the three. In view of the number of engineers and others present at the second test it seems justifiable to take the loads and engine weights stated in the accounts as reasonably accurate. Hitherto there has been a general tendency to suppose that the performances had to be taken with many grains of salt, but this is only upon a limited theoretical analysis of the figures; if the practical factors of locomotive design and performance are also taken into consideration a factual explanation can be found.

The accounts of the trials refer to the number of men upon the tender and vehicles of the train—in the first trial "24 persons who were on the Tender and Burthen Car"—and it has only to be assumed that there were three men on the footplate and three men towards the front end of the tender of the "George Washington" to produce a remarkable change in the adhesion situation. This change is shown diagrammatically in the upper portion of Fig. 1 from which it will be seen—assuming that the drawbar between engine and tender was adjusted in such manner that *additional* weight bearing down the front end of the tender was transferred to the rear end of the engine—to produce the figures shown in the diagram. As will be seen, owing to the length and axle distribution of the Norris engine in general, and the assumed design of the "George Washington" in particular, the centre of gravity moves back no less than 6½ inches. Under these circumstances, applying the newly-found adhesion weight to the first and second tests we get a factor of adhesion of 1 to 4.2 and 1 to 3.2 respectively—the increase in adhesion weight being, on this ground alone, no less than 1776 lbs. or 20%.

When the engine was exerting the necessary tractive effort on the climb—some 2500 lbs. in the first test—the resultant effect of the two-level drawbar would be a downward pull at the drawbar socket at the rear of the firebox of some 340 lbs. and this when relationed to the position of the driving axle and the centre of gravity—already moved back by the effect of 6 men—would produce no less than 923 lbs. extra adhesion. Adding this extra down-haul upon the rear end of the locomotive obtained by the particular form of two-level drawbar used—plainly evident in Fig. 9—plus the "adhesion-men" already mentioned, the nominal adhesion weight of 8700 lbs. becomes raised to about 11,400 lbs. equal to an adhesion ratio of 4.56, sufficient to explain the puzzle of the first test. As the required tractive effort in the second test was 3370 lbs., there would be produced thereby no less than 1247 lbs. extra adhesion, and a final figure—assuming men upon the footplate etc. as in the first trial—of 11723 lbs. giving an adhesion ratio of 3.5 and hence the adhesion mystery of the second test is almost resolved. It will not escape notice that we have now arrived close upon 12,000 lbs. upon the driving wheels and as the whole engine weight is just under 15,000 lbs. it follows that—after allowing for the weight of the bogie unit itself—little weight can have rested on the bogie frame; this giving point to the remarks of Harrison mentioned previously.

Even after all this there is thus still some lack of adhesion to be made up for the "G.W's." second test—the third test is covered by the explanation of the first—and this can plausibly be bridged by some lesser factors not previously mentioned viz.:—the ordinary reactions of locomotives when steaming hard tend to "throw up" their leading ends, which would produce some effect upon the adhesion of an engine of this type, as would the additional proportion of water towards the rear end of the boiler when upon the incline, also the tyres were probably still somewhat fresh from turning; whilst the track being composed of strap rails—i.e. thinnish iron bars on wood scantlings—although increasing the rolling-resistance, would tend to furnish a better contact between the tyre tread and the rail. These additional factors can be considered sufficient to cover the remaining shortage of adhesion. The adhesion ratio of 1 to 3.75 for a two-cylinder engine adopted as the touchstone in the foregoing analysis may strike some locomotive experts as unreasonably low; it is however the case that the author has had plenty of two-cylinder locomotives operating successfully over very steep gradients with an adhesion factor around 3.8.

It is stated categorically in the account signed by those who took part in the second "G.W." trial "there is no contrivance as in some engines, for increasing the adhesion, by throwing the weight of the tender upon the engine—the axle being in front of the firebox preventing any such arrangement" and this "disclaimer" obviously refers to the "traction increasers" of E. L. Miller's patent June 1834 and G. E. Sellers of May 1835; the former taken over and jealously guarded by Baldwin, whose engines stood to benefit much more than the Norris although none of the extant Baldwin drawings show the application of the device. Incidentally the assumption that the effect of a traction-

increaser would be less because the driving wheels in the Norris pattern were further away is amusing—the effect was greater although the need was less—and it may have been a "hoodwink" as the Norris people themselves can hardly have been misled. Colburn stated in his Paper of 1869 (24), in referring to the "G.W." first trial of July 1836, that "it is believed that a portion of the weight of the tender was made to bear upon the footplate, thus increasing the adhesion." This of course is contrary to the Norris statement at the time; but Colburn may have had in mind the same "kinked" drawbar known to have formed part of the true Norris design and an "adjustment" between engine and tender, as suggested in this analysis.

All the available drawings of the true Norris show the "kinked" drawbar, excepting that of the pseudo "Victoria" of Hodge (see Fig. 4) which in fact shows a pin connecting the engine and tender in an impracticable manner—incidentally, assuming Hodge to have made or sponsored the drawing (he does not say Sanno *made* the drawing), lending force to the jibe of Sinclair that Hodge was not altogether a success with the Rogers firm.

Further on this point it is to be noted that Capt. Moorsom in his Paper of 1840 (9), when referring to the true Norris said, "The mode of attaching the tender to the engine was peculiar, and he considered it to be advantageous, as it threw a portion of the weight upon the engine and was an assistance in starting"; so it is evident that the drawbar expedient was a Norris habit. Whilst Harrison (1871) says, "the amount of extra weight that was thrown upon the drivers by the action of the draft-link connecting the tender with the engine—the result being that about all the weight of the locomotive rested upon the drivers, less the weight of the truck frame and wheels in front"; and even Sinclair, 1903-5 (34), spotted the drawbar influence saying "In addition to that [i.e. the greater part of the weight being on the drivers] the tender coupling was so arranged that part of the tender's weight was thrown upon the driving wheels when the engine was pulling."

Dealing now with the steam pressure; the question here being that of the safety-valves. The published statements regarding pressure have already been cited viz.: the first test "under 60 lbs.", the second test "less than 80 lbs."—with an additional remark later in the descriptive article "now usually works with 70 lbs. pressure" whilst a letter appearing in the "National Gazette" of July 21st, 1836 also referring to the second test remarks "Pressure under 80 lbs. to square inch; it is remarkable that the engine was blowing off, on her arrival at the top, having acquired speed and power on the ascent"; whilst in addition to "pressure in the boiler was under 70 lbs." given by the "Pennsylvania Inquirer" for the third test, this same run is referred to in the "National Gazette" of Oct. 19th, 1836 as "pressure in the boiler under 70 lbs." with the further comment "performed to the complete satisfaction of numerous scientific gentlemen, invited expressly for the occasion." It is clear therefore that there must have been readings of these pressures indicated upon the safety-valve gauge or the discrepancy would have been noticed by someone.

Directing attention to the proportions of the Norris safety-valve in particular and to contemporary U. S. practice as exemplified in Hodge 1840, a factual explanation of this mystery also becomes evident.

It must be remembered that the safety-valve control, i.e. the spring-balance, was the indication of the blowing-off pressure only; that is to say to whatever degree the spring-balance was extended by means of screwing down the top thimble upon the lever the indicator would *not* move up and down as the steam pressure varied but would remain still at whatever the safety-valve was ostensibly set at until actual blowing off occurred when an upward movement corresponding to some 5 lbs. would occur.

A careful scrutiny of the safety-valve used by Norris—all contemporary views show only one spring-balance safety-valve on top of the firebox—discloses the fact that its diameter was apparently 2 in. corresponding to 3.1416 sq. ins.; whilst the appearance of the spring-balances shown on all the earliest contemporary drawings is decidedly that of the ordinary "household" or "retail shop" type, and these contemporary drawings—by the firm itself—show the safety-valve levers as $2\frac{1}{2}+21''=23\frac{1}{2}$ ins. total and this gives a leverage of 9.4 to 1.; see Fig. 2. These proportions of leverage and area would produce a pressure per square inch in the boiler exactly three times the reaction on the end of the lever and thus an ordinary hanging spring-balance scale would correspond to three times the steam pressure in lbs. per sq. inch for each lb. mark upon the scale. Hence the extraordinarily significant reference "not in triplicate proportions" appearing in an order for copies of Norris engines built in England—referred to below—makes the suggested explanation practically unassailable.

The common acceptance at that time of an ordinary commercial spring-balance as part of a safety-valve for steam boilers in America, is apparent from the explanation of safety-valves given in Hodge's book, where he shows a drawing, here also given in Fig. 2, in which the proportions of lever and valve coincide with equality of pressure in the boiler and lbs. upon the scale—he also gives "rules" to the same effect, not required to be repeated here.

The Norris safety-valve lever providing a 9.4 to 1 leverage, a 2 in. diam. valve would allow a pressure of steam in the boiler just three times that indicated on the spring-balance as stated, whilst assuming a $2\frac{1}{2}$ in. diameter valve the proportion would be just over 1.9 times the spring-balance reading. This means that with the balance reading 58 lbs. the real pressure in the first case would be 174 lbs. and in the latter 111 lbs.—the valve would need to have been almost $3\frac{1}{2}$ inches diameter to correct the discrepancy. It is just possible that the divisions on the balance were re-marked—but incorrectly; for instance 60 being (correctly) substituted at the 20 lbs. marking; there would then be a correct pressure at that point but if the 30 lbs. were marked 70 and the 40 lbs. marked 80 and so on these two latter would represent pressures of 90 and 120 lbs. respectively.

Beyond the explanations given above, references are convenient to the following extracts from contemporary documents. Mc.Connell in

his remarks on a Paper of 1849 (18) referring to "one of the small American engines" on the Birmingham & Gloucester Rly. of England said: "The pressure, however, on the American engines was very fallacious, for the spring-balance only indicated about one-third of the actual pressure on the boiler, which was really about 100 lbs. per inch." Whilst in the order given by the same B. & G. Rly. to Messrs. Nasmyth & Co. of Manchester, England, for the construction of some Norris type engines in 1840 there appears this stipulation, "". . . the engines shall be made like the sample engine "Victoria" . . . and the scale of each of the (safety) valves [there were two on these Nasmyth engines] shall be graduated so as to show directly in figures the pressure of steam in the boiler per sq. inch and not in triplicate proportions . . ." "

Much later, H. T. Walker, well-known U. S. A. locomotive historian of the early 1900's, in 1909 (39) referring to the Norris engines sent to the B. & G. Rly. mentioned that critics claimed the supposed 62 lbs. pressure was really over 100 lbs. and added, "There was, doubtless, some truth in this assertion, as the present writer has been informed by old engine-drivers in the United States that at least one firm of American builders, in order to obtain the reputation of building "smart" engines, constructed their spring-balances in a way so that when steam was blowing off, the actual pressure in the boiler was far above that to which the index was set." Whilst Sinclair 1907 (36) referring to early locomotive feats said, "Those being the days when . . . the veracity of enginemen when dilating about favourite locomotives was on a level with the angler describing the fish caught."

That Sinclair had reason for his remark appears from some of the testimonial-letters respecting Norris engines printed at the end of the firm's Circular of 1838, one driver stating he had run the "W.C.F." for six months "during which time (with the exception of only three days) she never lost a trip and the whole expense for repairs for the six months does not exceed twenty dollars," and another that he had "run the 'Lafayette' by Norris for five months and three days . . . every day except four days with full trains . . . never lost a trip and the whole cost of repairs for the 5 months 3 days did not amount to one dollar." The statements themselves are remarkable as is also the fact that they are each by different drivers named Donahue, whilst perhaps more remarkable still is that an official report of an accident to one of the Norris engines supplied to England refers to "one of the American drivers Donahue sent with the engine."

It may be noted that in the "addenda" to the 1836 account, by the Editors of the "American Railroad Journal," of the second trial (2) it is stated "Mr. Norris considers that these fine effects are owing to an improvement in the adjustment of the valves—which he has attained—after a long series of experiments," which has almost a modern "talking-point" ring about it. As to the Norris (later) special form of expansive valve-gear, it would not have affected the hill-climbing of such a relatively short distance and further, there is little evidence that the special Norris arrangement was applied to these locomotives of that period, all illustrations showing simple valve motion.

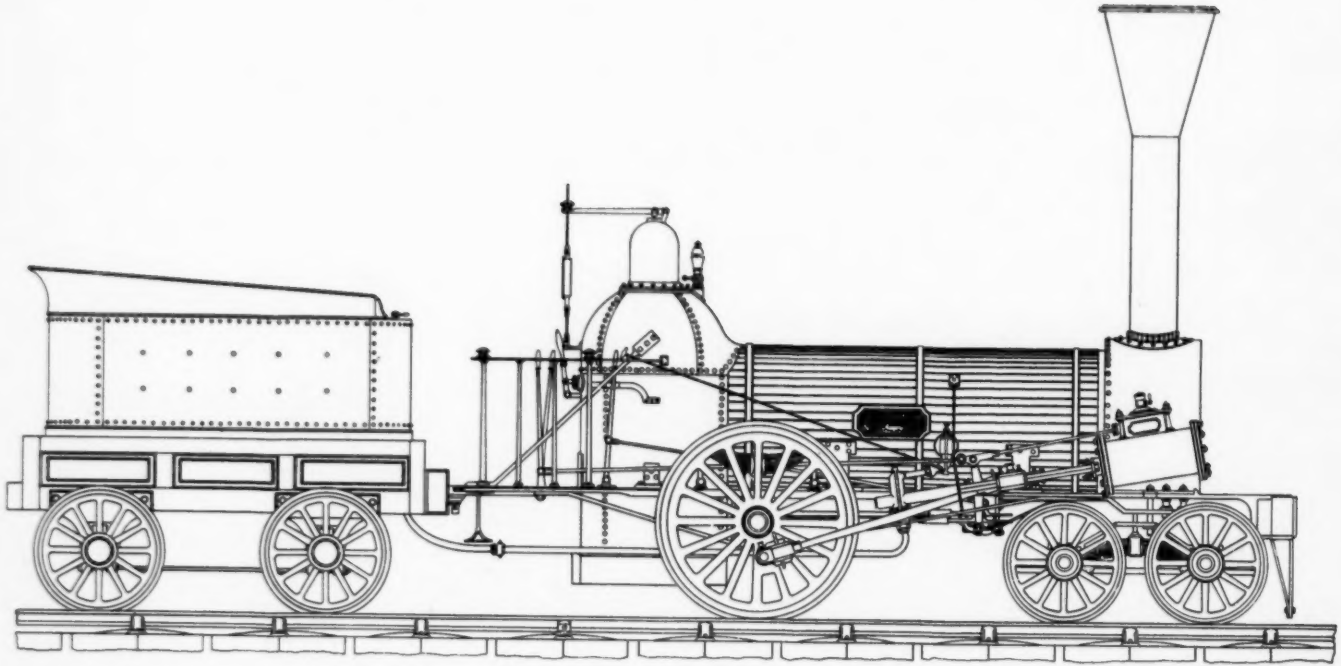
That these engines were not capable of their accredited performances if the pressure etc. had really been those ascribed to them, is further supported by trials of some of the engines similar to "W.C.F." supplied to England in 1839, in which—under circumstances where the steam pressure was more closely controlled—they generally failed to meet the much easier conditions there prescribed. There is of course nothing new in the demonstration of impossibility under the *supposed* conditions; most locomotive engineers having recognised the fact, as for instance D. K. Clark 1855, Colburn 1871, the "Railroad Gazette" Feby. 1887 (in commenting on the interesting exposition of the Norris Locomotive of 1836, appearing in the same issue) amongst the early commentators, but under what conditions it really could have been done has apparently never been studied hitherto.

It seems generally assumed that there was only one of the distinctive "George Washington" pattern—of July 1836—followed by the "W.C.F.", "true" Norris, in October 1836, but it seems clear there were other "G.W's.", the "Benj. Franklin," "Robert Morris" and "James Madison" to the Phil. & Col. R. R. already mentioned, and there exists the possibility that the "Wm. Penn" was also similar to "G.W.", so that it is not even certain that the "G.W." was the *first* of its pattern! Hence it is much to be lamented that no information as to what any of those various engines were really like has survived, not even in U. S. A. where a number of locomotive historians have interested themselves in the matter since the early 1900's.

THE "TRUE" NORRIS 4-2-0 PATTERN: GENERAL DESCRIPTION AND REFERENCE TO EXTANT ILLUSTRATIONS

The general design of the true Norris is well-known, but there are interesting constructional features, consideration of which is worth while; but as such can conveniently be combined with the constructional features of the early Norris 4-4-0 type, the subject is dealt with more fully in subsequent sections. Regarding the 4-2-0 it may here be mentioned that "the work was plain" (9), was "got up almost without the use of a file by lathes and planing machines" (6) which is certainly a tribute to the Norris Works at such an early date, and that David Joy in his reminiscences (38), referring to an occasion when he saw one of these which had originally been on the Birmingham & Gloucester Rly.—but was then employed around a Colliery—that "the little thing could pull, but she was odd, plenty of cast iron in her, even the cross-head pins were cast iron." Nothing was jacketed except the barrel of the boiler, which was covered with beaded boards painted and held in place by bands of polished brass. There were no sandboxes, which seem to have come in about 1846 in the U. S. A., although sandboxes were added to some of the Norris engines in England in 1840. The inside fireboxes were of iron.

Some illustrations show a spark arrester composed of simple netting about the chimney top, whilst others show an early form of the "diamond-stack"; in some of the earliest engines sent to Germany the



SCALE ¾ INCH TO THE FOOT

Figure 4

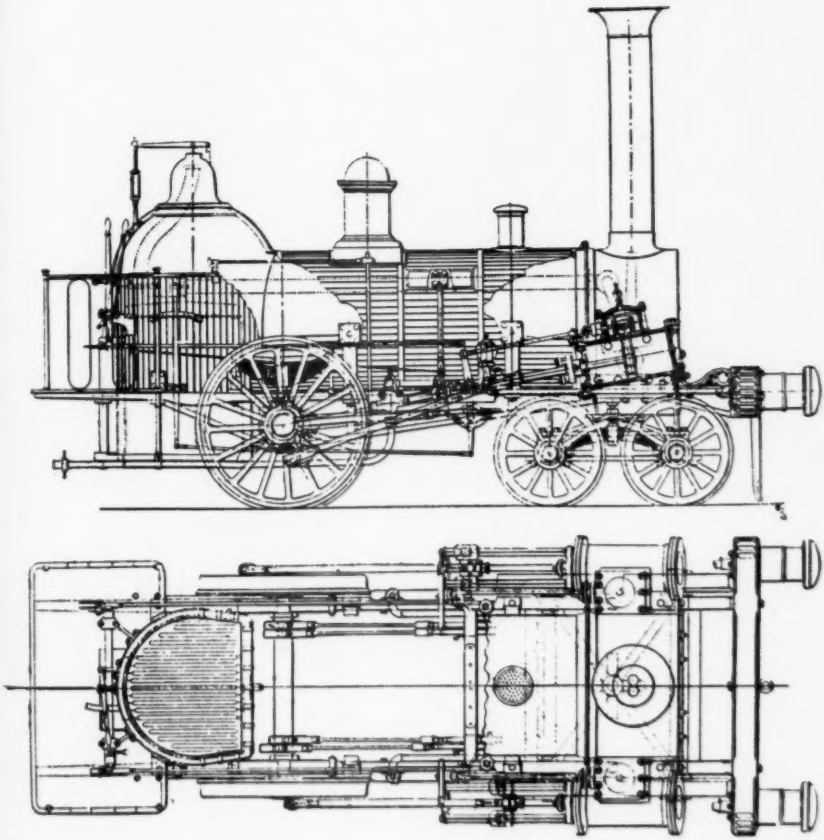


Figure 5

"diamond" was at the lower end of the chimney, this evidently being for the purpose of lowering the upper portion above the "diamond" in order to pass under bridges; this latter arrangement was also used in some cases in U. S. A. having been devised there by Schultz in 1836, and a photograph exists—unfortunately inadequate for reproduction—in which a coiled spring is shown at the hinge evidently for the purpose of restoring the upper portion of the chimney to the vertical after it had been pulled down—like the Thames river tug-boats in England.

Study of the general Norris features will be assisted by consideration of the various known illustrations.

From diverse "outside" sources it appears there were four sizes of the true Norris 4-2-0 and this is corroborated by a table in the firm's "Circular of 1841 (10) in which they appear as classes "A EXTRA," "A," "B," and "C," from which the principal dimensions are reproduced in Appendix 4. It is to be remarked that the original "Geo. Washington" was evidently in size, but not in design—as before mentioned—equivalent to size "B" but with a boiler-barrel corresponding to size "C," whilst what may be called the "universal" drawings current in U. S. A. all show size "B."

It is remarkable that practically no drawings or illustrations of classes "A EXTRA," "A," or "C" exist—during many years the Author has failed to develop any of the two latter—although one or two really representing class "B" masquerade as class "A."

Of class "A Extra" a bare outline exists in Clark's "Railway Machinery" 1855 (showing it as later equipped with a saddle-tank) and is given here in Fig. 3. In a Paper by G. D. Bishopp of 1843 (14) of the Birmingham & Gloucester Rly. very minute details of one of this class are given, but although these were drawings exhibited at the time they cannot now be found notwithstanding a special search kindly made recently by the Secretary of the Institution in question; there is also a photograph of a later example of the class in Austria, which will be illustrated and referred to in the subsequent account of the exports to Europe. A drawing published more than once having the name "Philadelphia" has been sometimes supposed (erroneously) to represent the "Philadelphia" sent to England—which *was* a class "A Extra"—whereas the drawing derives from one given by a descendant of Norris in an article of 1887 (29) and really represents a class "B." Another drawing was published—republished really—in England in 1892 (30) also purporting to show this "Philadelphia" to the B. & G. Rly., but the drawing does not represent a Norris-built locomotive.

Regarding class "A"; there is an almost contemporary drawing carrying the name "Victoria" in Hodge 1840 (8) and as the only "Victoria" appears to have been an engine of that name supplied to the Birm. & Gloucester in 1839—which was a class "A"—it might be expected to represent that engine; this drawing (see Fig. 4) however represents a class "B" engine and is reproduced here partly to show the particular form of the firebox in which the diameter of the shell is practically the same as the barrel and thus not of the true "Bury" form. This Sanno-Hodge drawing also exhibits well the form of attach-

ment of the "B" type firebox shell to the boiler-barrel. The arrangement must have been a "pièce de résistance," literally, for the boiler makers of those days, appreciably more difficult than the true "Bury" form; but photographs taken later of many other examples are known showing practically the same system of plating as it was carried out in practice.

All the dimensions when scaled from the pseudo—"Victoria" agree with "Washington" and class "B" (see below), and as the "Victoria" in England is definitely known to have been class "A," the conclusion is inevitable that the drawing in Hodge shows an example of the smaller type with the name "Victoria" wrongly applied.

There is a difference of some interest between the drawings of "Washington" and the pseudo "Victoria" in respect to the pump-bodies, the latter showing the valve chambers square to the ram; as this latter is a defective arrangement for the ball-valves used in these pumps it might be considered good evidence that the design represented by "Victoria" is the earlier, although the form of firebox appears later than the "Washington." The author has no great confidence in this Sanno-Hodge drawing. It may be mentioned that the two well-known carvings on the tombstones at Bromsgrove in England—a station on the old Birm. & Gloucester Rly.—also exhibit these respective differences in the pumps. A photograph of these tombstones was reproduced in Bulletin No. 10, page 51.

Besides this and one or two others mistakenly-attributed to the class "A" size, no drawing of a class "A" emerges either from America or the European Continent, but fortunately this class was copied with great fidelity by Hick & Son of Bolton, England for the B. & G. Rly., and a drawing of these engines, given in Fig. 5, can be taken as representing the class "A" Norris with the exception of the sand-box and lock-up auxiliary safety-valve on the boiler-barrel.

The principal of the extant drawings of class "B," which can certainly be considered much the most numerous class built, are dealt with below, whilst regarding class "C" the author some years ago thought he had tracked down an actual locomotive of the class originally belonging to the Raleigh & Gaston R. R., at the Purdue University Museum U. S. A., but which eventually turned out to be a wooden model, name "Tornado."

In addition to the schedule of sizes in the 1841 Circular—and in copies therefrom in subsequent publications—there exist particulars of an offer made by Norris Bros. to supply locomotives to Wurtemberg, which show that the firm were also prepared to supply engines with different sizes of driving wheels both of their 4-2-0 and 4-4-0 types. Unfortunately, as far as the author is aware, few records of varying sizes of wheels which may have been used upon the 4-2-0 engines supplied to U. S. A. lines exist, such as are known give wheels 4/0 to 4/2 diameter. It may be mentioned in passing however that in the case of the "A" class engines—both those supplied by Norris and those built in England—upon the Birmingham & Gloucester Rly., most were afterwards—in 1841-1842—fitted with larger wheels of 4 ft. 9 in. and 5 ft. 0 in. diameters and, according to a Directors' Report of the period, the change had "in all respects succeeded."

The two "effective" drawings of the class "B" Norris are firstly "Washington," being a large plate issued with the Norris Circular of 1838, Fig. 6; this is the best of all the drawings, as is to be expected in view of it having emanated from the firm at the time they were actually building these engines. The other is a plate published in 1887 (29) with a letter from Henry L. Norris who was a descendant of the Norris Brothers; this illustration was evidently from accurate drawings and shows two end-views. There is also an excellent drawing representing one of these "B" class engines as supplied to Germany in 1839, which will be given in the subsequent account; this drawing, Fig. 15, shows internal views of the boiler etc.

Mention should also be made of the illustration on the title page of Norris' 1838 Circular. This picture, although a rather crude "engraver's" interpretation and faulty as to the mechanical details, has some interest. The name given, "Lafayette," is found applied to three Norris engines in the Congress Report of 1838, hence the illustration purports to represent one of the Norris engines built for the Carrollton, the Baltimore & Ohio, or the Allegheny Portage lines. This same illustration was evidently the origin of the plate preserved in the Austrian State Rly. Museum which carried the name "Philadelphia" and states it to have been built in Nov. 1837 and started work April 1838. A special point is the peculiar form of spark-arrester shown, and that this applied to various early Norris engines sent to the Continent is supported by the "technically correct" line-drawing published in Germany in 1842 in which an identical pattern of spark-arrester appears: this drawing will also be dealt with in a subsequent section. Many of the illustrations of class "B" are merely subsequent copies—most with fanciful variations, especially in later years. These later "variorum" illustrations are not noticed here.

A most interesting illustration appeared in 1896 (31); it is from a photograph showing Balt. & Ohio locomotive No. 16, a 4-4-0; this is undoubtedly the "Philip E. Thomas" built as a 4-2-0 in June 1838 but rebuilt a few years later as a 4-4-0, and because of its interest it is reproduced here as Fig. 7. It will be seen how the additional coupled axle was placed as close to the firebox as possible, that the old "hook" valve-gear was still in use, whilst the firebox was of the true Bury pattern—its domed upper portion being somewhat "tall," lending aid to the belief that some of the Norris engines exported to England also had this feature. See Fig. 8, which shows "England," the first Norris locomotive supplied to that country, in which the "tall" firebox appears.

DERIVATION OF THE "GEORGE WASHINGTON" AND OF THE TRUE NORRIS PATTERN "WASHINGTON COUNTY FARMER"

Having dealt with the design of the "G.W." and of the true Norris, it seems convenient to review the probable derivation of both the "G.W." and the "W.C.F." designs, the latter of which evidently developed sufficiently "automatically" from the former that they can be considered together. A survey of those patterns of locomotives constructed by the

various American firms prior to the "G.W." which are considered to have influenced the "G.W." and "W.C.F." is therefore attempted.

This survey naturally commenced with Baldwin's "Lancaster" of June 1834 for the Philadelphia & Columbia R. R. because with this engine commenced the so-much-used 4-2-0 type. The Lancaster class had outside main frames, of wood with flitch plates, and the cylinders were attached to the smokebox sides—and of course also to the framing—the driving wheels being behind the firebox with long connecting rods passing each side of the firebox to the well-known Baldwin half-crank, whilst the bogie, placed fairly central under the smokebox and cylinders, had an outside framing of wood. The boiler was of the Bury pattern with the true Bury form of firebox—already described—whilst the question of the introduction of the bogie in U. S. A. is dealt with further on.

Baldwin commenced using outside-connected engines, i.e. having the main frames inside the wheels—and here it should be noted that even with the customary American 4-2-0 with outside frames the cylinders compared with current British designs, could be, and sometimes were, referred to as having outside *cylinders*—in May 1835 in their No. 11 "Black Hawk" for the Philadelphia & Trenton R. R. and, from the fact that special mention is made in Baldwin's 1923 (43) that it was on their 136th locomotive completed in October 1839 for the Philadelphia, Germantown & Norristown R. R. that "the old pattern of wooden frame was abandoned and no outside frame whatever was employed." The wooden frame thenceforward disappeared gradually and an iron frame took its place; it seems that these early inside framed engines had wooden main-frames; it is also of course the case that they had driving wheels behind the firebox.

It is important with respect to possible outside connected 4-2-0 engines supposed to date 1834-5, to mention that the Patent Office model, of U. S. A. Patent (No. 540) of 1837 by S. Wright, shows such an engine and having driving wheels behind the firebox. This patent appears therefore to cover the features assigned to Baldwin's No. 11 of 1835; the model in fact represents what a true Norris would have been if the driving wheels had been placed behind the firebox.

There have appeared statements that some Baldwin engines, with outside frames but having the driving wheels in *front* of the firebox, had been built before this stage, but the author has not found sufficiently definite confirmation. The typical Baldwin of the 1839-42 outside-framed pattern with frames of bar iron by Messrs. Baldwin, Vail & Hufty 1841 is shown in Fig. 9.

There has been some belief that Baldwin's had used a bar-framed outside connected pattern some years earlier than 1841, in fact a drawing of one was published by H. T. Walker 1899 (R. I. 6) and there designated as Baldwin's "Black Hawk" No. 11 of May 1835 previously referred to; whilst the same drawing was later reproduced by Carruthers 1906 (35) as representing "Brandywine," Baldwin's No. 18 to the Phil. & Columbia R. R., which engine was no doubt similar to "Black Hawk," but cannot be taken as independent evidence for the bar framing. Walker's original drawing however was derived from a Baldwin adver-

tisement of 1839-40, by which time we know they had adopted the bar-framing, and it seems preferable to rely on the firm's own account and consider such Baldwin engines as were built at any rate prior to 1838-9 —even those with inside frames—as having the old pattern of wood framing. That there is nothing improbable in the association of the use of wooden- and inside-frames is evidenced by the well-known drawing of Garrett & Eastwick's 4-4-0 "Hercules" of 1837 (R. I. 7) in which such an arrangement is clearly seen. Further, in the same publication, by J. Harrison 1871 (25) he says that the same firm's first engine "S. D. Ingham" built 1835 for the Beaver Meadow R. R. "had outside cylinder connections, running-gear after the Baldwin type, with one pair of driving wheels behind the firebox, and with a four wheel truck in front." Hence as in their immediately following engines E. & H. used a wooden inside frame (vide "Hercules") it is probable the "S. D. Ingham" was likewise fitted and there must thus have been a considerable resemblance between it and Baldwin's No. 11 of 1835.

The "Lancaster" pattern was also built by other U. S. A. firms, as for instance H. R. Dunham & Co. in 1836 etc. (R. I. 1) the pattern cannot of course be considered a predecessor of the true Norris, although if the unproved suggestion that a Baldwin class with outside frames and the driving wheels in front of the firebox could be substantiated this latter would be a forerunner of—what the author suggests to have been —the "G.W."

The definite forerunners of the true Norris "W.C.F.", except of course in respect to the "Bury" boiler, are undoubtedly the three 4-2-0 engines built in 1835 by R. Stephenson & Co.—Stephenson's 114-116, drawing dated 1st April 1835—and three others evidently also to Stephenson's design, by Charles Tayleur & Co. (now the Vulcan Foundry) of Newton-le-Willows, for the South Carolina R. R. These were outside connected engines of the Norris type, although having odd-sized bogie wheels; there is however no true framing connecting the front of the engine with the rear, except obliquely-placed "longitudinals" between the cylinders and the small section of bar framing adjacent to the driving axle-boxes, the connection of the bogie being thus entirely via the boiler; the whole arrangement was a poor mechanical job from a locomotive point of view and simply cried out for the improvement of the straightforward inside framing as given by Norris to the "W.C.F." the year following. It should be noted that the adoption of bar framing —inside or outside—by Baldwin is considered to have been subsequent to these engines.

It should also be mentioned that a copy of the illustration of one of the Tayleur-built engines, named "Cincinnati," is given by Sinclair 1904 and again in 1907 (R. I. 9) where it is attributed to the "Niles Locomotive Works" of Cincinnati, apparently because of the name "Cincinnati"; the Niles Works started in 1851 and the connection is apocryphal. C. Sellers Junr. became Superintendent of these Works and it seems some confusion with the facts here given in the following paragraph must have caused Sinclair's lapse.

In 1885 (27) it was stated by G. E. Sellers one of the firm of Coleman Sellers & Sons who in the 1830's were established at Cardington near Philadelphia, that in 1835 they had built engines for the State line which ". . . had outside cylinders with a single pair of drivers behind the firebox and a four-wheel truck with a center bearing. The frames were of iron and the driving wheels had counter-balance weights bolted opposite the crank." Two locomotives by Sellers & Sons duly appear in the Congress Dec. 21 of 1838, built for the Phil. & Columbia R. R. in 1835, which are evidently the engines referred to. They were thus of 4-2-0 type with driving wheels behind the firebox (and Bury type boilers) in which outside connections were used and the inside frames were of iron, and thus forecast the *true* Norris in all except the position of the driving wheels. This appears to have been the first use of iron frames by a U. S. A. builder and no doubt the use of the bar frame in U. S. A. arose from the imported Bury locomotives of which there were a number on the Petersburg R. R. and the Richmond & Petersburg R. R., as well as some half-dozen distributed on various other lines, dating from 1832. The statement that the Sellers had balance-weights in the wheels, if correct, would make them the earliest examples of the use of such in any country.

To sum up; of the four leading features of the true Norris pattern viz.: outside connections, leading bogie, bar framing, and position of driving wheels, undoubtedly the first three were anticipated both by Sellers and the Stephenson-Tayleur designs of 1835, which latter anticipated all four with the exception of the discontinuity of the bar frame, whilst the boiler was similar to Baldwin's and other U. S. makers of the period, deriving originally from Bury; thus there was no one item intrinsically novel in the design. This, in fact, is believed to have been the Norris firm's own view, i.e. that the design was a judicious combination of the best features available in the development of locomotive design at that period. Regarding the "George Washington" itself, as before-explained, this must have been an inside-connected engine, so that the "record-breaking" engine itself was in some respects a lesser developed design than some of its contemporaries.

Compared with the Baldwin, the Norris type naturally possessed greater adhesion, whilst the former with their long wheelbase were steadier and less punishing to the track. Baldwin's use of the "traction increaser" has already been mentioned and his No. 11 of May 1835 is believed to have been the first locomotive so equipped. Owing to objections raised to the adverse effect upon the track by the Norris type, a few engines were built—by Rogers in 1842—of a typical Norris pattern but with a pair of uncoupled trailing wheels added; one of these was the "Stockbridge" of January 1842 (maker's No. 36) to the Housatonic R. R. and some went to Cuba (R. I. 10) where they followed closely on the heels of Norris-built 4-2-0's. Baldwin also built some engines of the 4-2-2 type but with outside (bar) framing, of which one, Baldwin's No. 146 of 1841, apparently for the Morris & Essex R. R., has additional points of interest—as also features unusual with Baldwin (R. I. 11). Its peculiarity in this context is that there was an arrangement by which

the weight—and apparently the whole rear-axle assembly—could be raised by means of gear upon the engine frame, and so allowing the whole weight of the rear of the engine to rest upon the driving wheels, thus providing an engine which was a "Baldwin's" or a "Norris" at will! The normal 4-2-2 type was also built by Borsig in 1841 and this will be dealt with in the subsequent account. These 4-2-2 engines were of course lacking in adhesion and could—if that type had not already been developed—have led directly to the 4-4-0.

INCEPTION OF THE "BOGIE" IN THE U. S. A.

Although the bogie became so early an outstanding feature of American locomotive practice, and in the Norris type it contributed greatly to the popularity of that type in Central Europe, its true inception has been obscured amongst incomplete references from an early date to even within the last year or so when final judgment seems at last clear; perhaps therefore as the story is dispersed through many publications, a final résumé here will not be otiose.

There can be no doubt that the four-wheeled bogie—or truck as it appears always to have been called in the U. S.—as applied to engines or vehicles on rails originated with the British patent of W. Chapman in 1812, drawings of which were published in 1936 (48) and which drawings the author knows emanated originally from the Butterly Co. Derbyshire; there seems also little doubt that the Chapman bogie was used on a number of early locomotives shortly afterwards (50)—from which time it disappeared to such an extent from British locomotive and railway practice as to give apparent grounds for the supposition, at one time current in the U. S., that the bogie-truck was invented there.

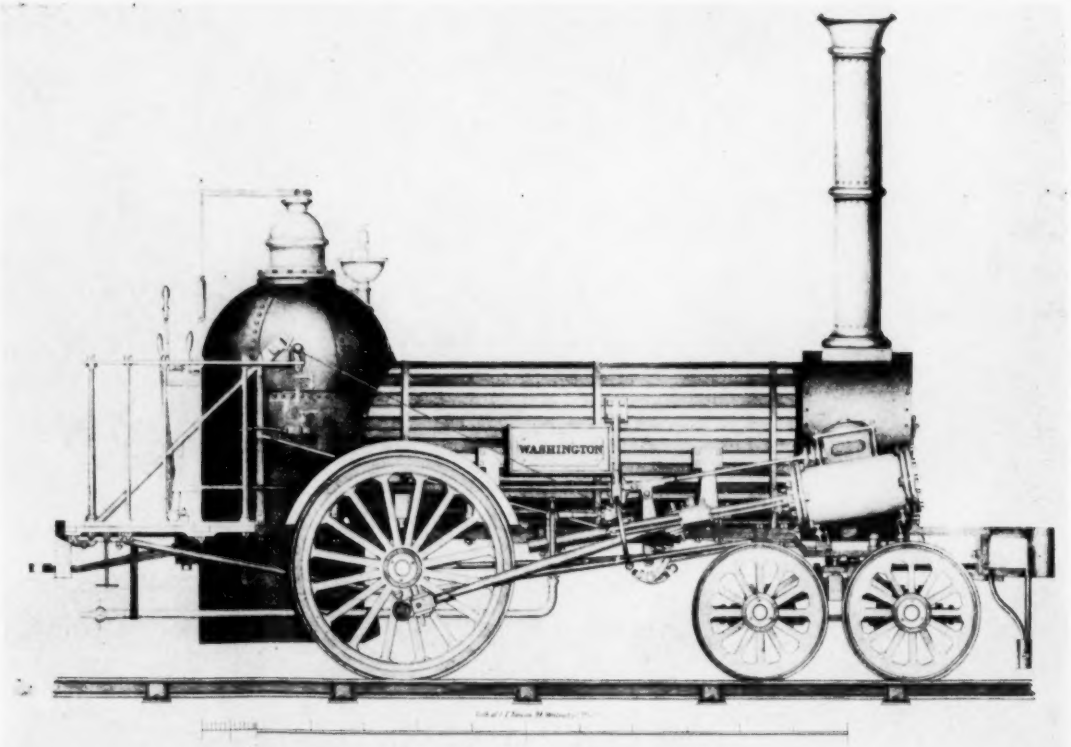
The idea that it was invented independently in America by J. B. Jervis begins with his own statement in 1866 that the employment of a leading bogie, called by him a "guiding truck," was planned by him in the Autumn of 1831 and that a design in which it was included was sent to Stephenson's who incorporated it in the locomotives they delivered in 1833 to the Saratoga & Schenectady R. R. However, in 1886 M. N. Forney stated (28) that the use of a bogie was proposed in a report of May 16th 1831 to the South Carolina R. R. by Horatio Allen, who had been at Stephensons Works, Newcastle-on-Tyne in 1828, and it must also be remembered that the earliest 2-2-0+0-2-2 supposed articulated locomotive by Allen himself for the South Carolina R. R. was built in the latter part of 1831; Forney goes on to say that Jervis invented what he (Jervis) called a "new plan of frame with a bearing carriage, for a locomotive engine for the use of the Mohawk & Hudson R. R." and that the engine started service in 1832, whilst we know from other sources that this engine was built by Adam Hall at the West Point Foundry in August 1832. Further, Forney also says that a "truck" was devised by Ross Winans and applied to a locomotive on the Baltimore & Susquehanna R. R.—apparently the "Herald" by Stephensons—in the latter part of 1832, but this was not a true bogie truck as will be seen further on.

Further statements, not contemporaneously made, but under the authority of Z. Colburn, also exist. In Clark and Colburn, 1860 (23) and Colburn 1871 (26) it is stated that in Allen's locomotives, each group of wheels "was placed under a swivelling frame which carried the corresponding end of the boiler on a pivot and side rollers." He then goes on to state that "In August 1832, an engine called the 'Experiment' was placed upon the Mohawk & Hudson R. R., having been the first ever built in America, with four swivelling carrying wheels substantially as now used under all American passenger engines." He adds that the "Robert Fulton" of the Mohawk & Hudson R. R. was altered in the winter of 1832-3 and, under the direction of Jervis, "fitted with a truck similar to the 'Experiment'," and re-named "John Bull"; and that in September 1832 "A truck frame, arranged to swivel on two side pivots—the motion resembling that of a parallel rule—was applied to an English engine, the 'Herald' " upon the Baltimore & Susquehanna R. R.

Hence, from documents, the order of the earliest adoption of the bogie in America would seem to be—excluding Allen's 2-2-0+0-2-2 of 1831 as not comprising true trucks or "bogies"—(1) Jervis's 4-2-0 by West Point Fdy. for Mohawk & Hudson, August 1832; (2) Jervis's two 4-2-0's by Stephenson for Saratoga & Schenectady, built 1832—delivered 1833; and two similar engines (designed probably by Stephenson) by Tayleur of Newton, Lancashire, at the same time for the Philadelphia & Columbia R. R. (but later sold to the Camden & Woodbury R. R.); (3) Ross Winans' addition, in September 1832, of a "truck-frame" which was apparently a forerunner of the Baldwin "flexible beam truck" of 1842—and thus not a single (centre) pivot bogie—to an engine of the Baltimore & Susquehanna R. R.; and (4) Jervis's application of a bogie to the "Robert Fulton"="John Bull" of the Mohawk & Hudson R. R. during the winter of 1832-3.

The exclusion of Allen's "articulated" is because when attempt is made to combine the drawings supposed to represent the "South Carolina" with the description they "do not fit"; Forney's description (28) states, "Each truck had one cylinder which was in the middle of the engine and attached to the smokebox. The driving axle had a crank in the middle . . . The trucks were connected to the engine by king-bolts in the usual way." As the driving axles were just below the undersides of the "twin" boiler-barrels it was not possible to have the connecting-rods working below true bogie-pivots; hence it would appear—as indeed Forney's accompanying drawing (R. I. 12) shows—that the weight was taken on side-bearers. There are thus too many incompatibles and so the U. S. A. honours must needs go to Jervis. Incidentally Hodge, in book of 1840 (8) insinuates that the "truck frame" (i.e. bogie)—of which he gives 3 plates—was first applied by David Mathews on the Mohawk R. R. and that "the English manufacturers are now using it"!

In Colburn's Paper of 1869 (24) he stated that Robert Stephenson informed him that he (Stephenson) had suggested the bogie to the engineers of the Baltimore & Ohio R. R. (not then begun) who were visiting England in 1828, going on to remark, "The bogie, which had grown out of William Chapman's invention of 1812 was then in regular use upon



LOCOMOTIVE STEAM ENGINE of WILLIAM NORRIS, PHILA.

CLASS B.

Figure 6

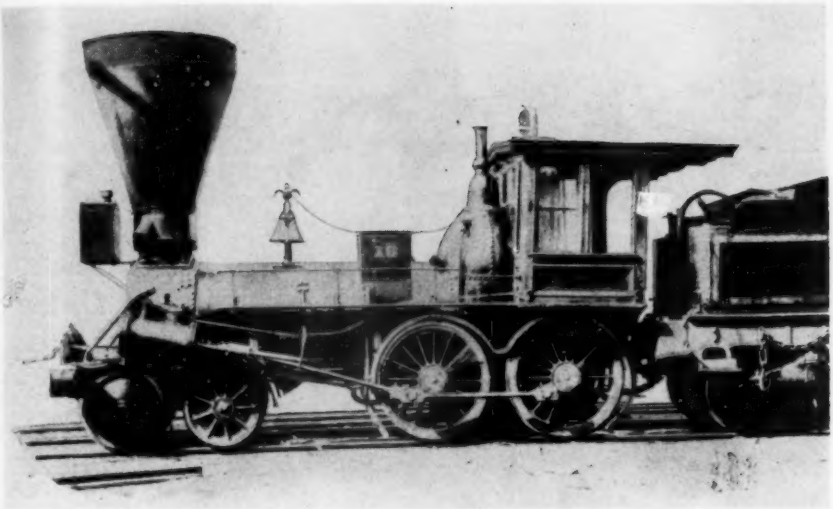


Figure 7

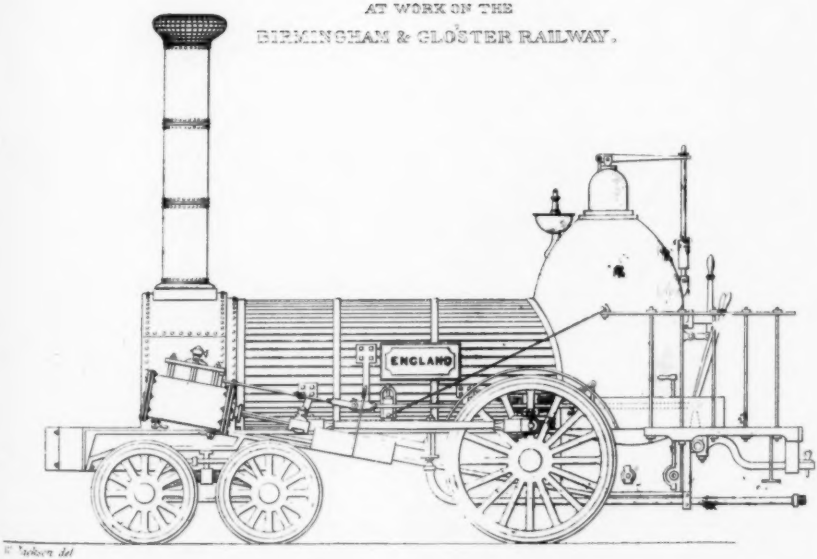


Figure 8

the ways of Newcastle." Although therefore there seems little doubt that the actual use of the bogie in U. S. commences with its introduction by Jervis, Colburn himself had no doubts about its actual origin. It will thus be seen that, the tradition and use of the bogie having been kept alive in the Newcastle area down to 1828, as must be assumed from R. Stephenson's statement—and from Allen's report cited by Forney—then its adoption for American engines by practically all U. S. builders in the years 1832-3-4 was a natural result of the track conditions there at the time. Perhaps after all, as Mr. J. J. Birckel remarked in the discussion on Colburn's Paper referred to, there was nothing really remarkable in the adaptation of the bogie to railways in view of its centuries-old use in two-wheel form on road vehicles.

THE EARLY NORRIS PATTERN 4-4-0 IN THE U. S. A.

This type of course originated with H. R. Campbell's engine built in 1836 by J. Brooks in Philadelphia and put to work on the Philadelphia & Germantown R. R., in which the cylinders were inside under the smokebox; there was outside—wooden—framing and the boiler was of typical English pattern. The next development was with the new firm of Garrett & Eastwick (of which Harrison shortly afterwards became "engineer") who turned out an engine of this type but with outside cylinders and inside wooden "flitched" framing in 1837, and followed this up in 1839 by a generally similar engine but having bar framing and with the rear coupled axle under the firebox; the cylinders of the Eastwick & Harrison engines were located at the side of the smokebox over the leading bogie similarly to the 4-2-0 "W.C.F." Norris of the same period.

Norris's first 4-4-0 was either the "Vesta" for the Baltimore & Ohio R. R. (Railway No. 25) of November 1839 or the "Pittsfield" for the Hudson & Berkshire R. R. built about the same time. A letter of December 1839 in the "American Railroad Journal" when combined with a Baltimore & Ohio R. R. locomotive roster of 1850 seems to suggest the "Pittsfield" was a coupled engine, whilst on the other hand the records of the Western R. R. and Von Gerstner seem to indicate that "Pittsfield" was like the other two engines, which were of the 4-2-0 type; the point is a relatively minor one as it is evident that the first Norris 4-4-0 was turned out at nearly the end of 1839—not as early as 1837-8 as has sometimes been stated due to confusion with Norris 4-2-0 engines of those years which were subsequently altered to coupled engines. There was a "Virginia," type unknown, supplied to the Richmond, Fredericksburg & Potomac R. R. about the end of 1838, but this seems of too early a date to have been a 4-4-0; whilst in the article by H. L. Norris before referred to (29) he states in reference to the earliest Norris 4-4-0 type, "An engine on this plan was first built by Wm. Norris for the Guanabacoa R. R. of Cuba in 1840," and this supports a date around the turn of 1839-1840. "Further, in an open letter published in a Liverpool (England) newspaper of the time, and signed by G. A. Nicholls, Supt. of Transportation, Philadelphia and Reading R. R. Janu-

ary 18th, 1840, there are given the distributed weights of a Norris locomotive named "Minerva," in which 'inter-alia,' appears "Weight on four driving wheels [in working order] 17,900 lbs."

It has generally been supposed that the foregoing and their immediate successors were on the lines of a design of which a drawing—"Philadelphia"—appears in an authentic Circular of the Norris firm dated 1843, but the earliest authentic drawing of the earliest Norris 4-4-0 design appears to be that given in a German publication of 1844 (16) "Virginia," and this drawing is undoubtedly of an engine earlier than one entitled "Philadelphia" just mentioned and here reproduced in Fig. 10. These early Norris engines can be elucidated in point of progressive design by noting certain details, primarily the manner in which the motion-plate is carried, and additionally by the number of supports between the main frame and the boiler as well as the particular form of the whistle. Comparison of the drawings shows at once that "Virginia" has the motion plate depending principally from the boiler-barrel, which is the system deriving from the Norris 4-2-0 engines, whilst "Philadelphia" shows the motion-plate attached directly to the main frame, and as this was the system continued subsequently it, taken together with the manner of connecting the boiler and framing with two supports each side instead of three as in "Philadelphia" and the form of the whistle previously mentioned, proves that the "Virginia" is prior to the "Philadelphia"; further, taking into account that the drive is to the rear coupled wheels, an arrangement not subsequently reverted to by Norris—even when he placed both pairs of coupled wheels in front of the firebox—and that it is in accordance with Eastwick & Harrison's 4-4-0 current (and prior) practice of the time, it is believed that "Virginia" represents the earliest pattern 4-4-0's which the Norris firm built. Contemporary support of this is that C. Ghega of the German publication referred to—he was Chief Engineer of one of the Austrian railways—was in U. S. A. studying railways in April 1842; whilst much more recently Snowden Bell 1912 (40) says that the early Norris 4-4-0's on the B. & O. R. R. were like Eastwick & Harrison's "except as to reverse gear and outside spring truck"; and as the E. & H. engines were rear-drivers he would almost certainly have mentioned it if such a difference had existed.

Around these years another Norris 4-4-0 type is recorded in a drawing, from Sinclair 1907 (36), of the locomotive "Orange," Fig. 11, one of a pair, of about 1842, for the Erie R. R.—Cyls. 10¾x18, Drs. 4/6, in which a further development is seen, as this engine, whilst retaining the motion-plate arrangement of "Virginia," has the boiler supports of "Philadelphia" and drives on to the leading pair of coupled wheels.

As will be apparent, "Orange" is shown with a normal pattern of main-frame having separate springs above the driving and trailing axle-boxes, but in "Virginia" and "Philadelphia" we are introduced to a remarkable feature which does not appear to have been commented upon before by locomotive historians, which is that the coupled axles are grouped in an entirely separate sub-frame connected to the main frame by long and stout radius-bars with their front ends attached by hori-

zontal pins to the main frames slightly to the rear of the cylinders; the axles have no independent vertical movement in their sub-frame, one spring being provided above the main frame on each side of the engine with the lower end of the spring-pillar arranged to slide upon the upper surface of the side member of the sub-frame. In this manner, whilst both springing and equalizing effects were provided for the coupled wheels, their movements were not truly vertical but constrained about an arc having its centre near the cylinders, and thus variations in valve events, otherwise of some consideration with steeply inclined cylinders, were almost entirely eliminated. That the arrangement was not adopted merely for cheapness seems certain from the rather elaborate and costly sub-frame details; it looks like an avoidance—at any cost—of the Harrison (patented) equalizing systems.

An independent sub-frame for the coupled axles was the first arrangement for 4-4-0's by Garrett & Eastwick (vide "Hercules" R. I. 7) but was very soon abandoned for a true form—Harrison's—of equalizing levers (vide "Mercury" and "Gowan & Marx" R. I. 13 and 14) having axle-guides integral with the main frame, and by 1839 the firm was using the bar frame—in a like manner to the author's opinion regarding Baldwin's change of practice respecting frames. This remarkable Norris feature is not known by the author to have been used by any other locomotive builder, although Norris himself seems to have incorporated it shortly after in some special 4-4-0 designs intended—but perhaps not built—for some of the lines in Europe, described further on in the account of the Norris locomotives in Europe. Extant illustrations of Norris-built 4-4-0's in Europe show normal main framing and so it is not certain whether any of them had this remarkable sub-frame; a matter which—at least as regards the U. S. A.—may perhaps be elucidated by American locomotive historians from data possibly existing there.

It may be interesting here to give the wording appended to the lithograph of "Philadelphia" (Fig. 10) viz.: "William Norris & Co. Improved Eight Wheel locomotive with Patent Flexible Truck. Manufactured at their Works, Bush Hill, Philadelphia 1843." Snowden Bell 1912 (40) thought the patent referred to was one R. Imlay 1837 covering cylindrical centre bearings and other features; this may be so—the author not having had opportunity to consult the Patent Specification—but it is considered more probable that the "patent" feature was the unique arrangement above referred to—which may, of course, form part of Imlay's patent.

In these first examples of the 4-4-0 "Norris" the two-bars-athwart pattern of crosshead was used including the firm's usual means of adjusting the "slippers" by set-screws, but in the case of "Philadelphia" the slidebars appear to have been round instead of square. Otherwise the motion, valve-gear, pumps etc. remained as in the 4-2-0 engines except that coupling-rods were provided of a built-up twin rod pattern having a collection of nuts and adjusting-screws apparently doomed to be trouble-causing, but which nevertheless continued as a Norris feature until about 1848 and was also adopted in their early designs by some

of the Austrian builders. The bogie, however, whilst upon the same principle as in the 4-2-0 engines, had its pivot only very slightly in advance of the centre of the bogie wheelbase.

Whilst the boilers of "Virginia" and "Orange" were of true "Bury" pattern similar to most of the 4-2-0 type, in "Philadelphia" we are introduced to the particular type of firebox—the "B" pattern—in which the length outside at the bottom is equal to the diameter of the domed upper portion; the method of connection between the shell and the barrel being clearly apparent in the drawing.

The later pattern of Norris 4-4-0, that is to say of the 1845-8 period and before the true "makers-design" had become influenced by the railways, is shown in Fig. 12. In this the third, or "C" form, firebox is well exhibited; there is a fixed main-frame—with equalizer—for the coupled axles, the 1844-6 pattern of slide-bars is shown as also the drop-hook gear with reversing-shaft below and with "riding" cut-off valve; the bogie is much changed and its pivot appears central but the two-bar coupling-rods persist. It is precisely a 4-4-0 edition of the 4-6-0 "Chesapeake" of 1846 referred to in a later section and thus confirms that new designing ideas were introduced on the departure of W. Norris to Austria. On this drawing appears for the first time a spring-balance for the safety-valve of pukka locomotive type!

A very similar engine, of 1848 for the Phil. & Columbia R. R., "Tioga," has been frequently illustrated (R. I. 15), which differs only in that the firebox is of "B" form and the coupling-rods are of normal pattern; the safety-valve spring-balance being however of the "household" type.

It is not proposed to continue separate notices of the constructional features of the Norris locomotives in America but combined references concerning the boilers, valve-gear, slide-bars and bogies of both the 4-2-0 and 4-4-0 types here follow; apart from which however some features will be reverted to when dealing with the development of the Norris-pattern locomotives in Europe.

CONSTRUCTIONAL FEATURES AND DIMENSIONS OF THE NORRIS 4-2-0 AND 4-4-0 LOCOMOTIVES

To the general considerations already given regarding the design of the true Norris, a survey of their constructional features is desirable and this may well commence with the boiler, or rather the firebox part of it, as the later, 4-4-0—and other—types are embraced therein. Although the Norris, as also Baldwins and many other early locomotive boilers of U. S., definitely derive from Bury, his particular form was departed from at an early date by Norris whose three principal patterns can be described as follows:—

Style "A": Diameter of hemispherical top greater than the diameter of the boiler-barrel, of true "Bury" pattern having the lower part of "D"-form with the throat-plate a much *less* distance in front of the vertical centre-line of the whole firebox than that of the truly semi-circular part to the *rear* of the centre-line.

Style "B": as "A", but diameter of hemisphere generally the same as the boiler-barrel and with the throat-plate about the same distance from the vertical axis of the firebox as the rear part, although the lower part and the grate still being of "D" form.

Style "C": Diameter of hemispherical top *less* than that of the boiler-barrel and having its centre-line to the *rear* of the midway distance from front to rear of the lower portion of the firebox.

The first-named is a fairly straightforward construction job but the two latter called for remarkable contortions in the shell-plating; this is well seen in the drawing of "Philadelphia" 1843, 4-4-0 (Fig. 10) showing Style "B" where the front upper portion of the side-plate has to be set-in to accommodate itself both to the transverse circumference of the barrel and to the horizontal circumference of the firebox; whilst in the case of style "C," the drawing of "1847," 4-4-0 (Fig. 12) and photographs of later-built Norris boilers show how the only way to meet the poor design was to interpose an "apron-plate" worked to a shape to accommodate the three discordant curvatures. The lower part also of "B" and "C" must have provided further examples of tortured plates in bringing other incompatible plate junctures into order.

All drawings of Norris-built 4-2-0 of designs up to 1840 known to the Author show style "A," with the exception of the drawing in Hodge 1840 (Fig. 4) which shows style "B," which drawing however for reasons explained should be received with caution, whilst on the other hand, with the exception of "Virginia" and "Orange" two early—1841-2—productions and possibly a few later sent to Europe, no drawings of Norris 4-4-0 show style "A." Style "C" first appears about 1846 and the firm continued using the two "debased" forms up to 1851-2. Mention should be made of the possibility that some of the early 4-2-0's had a somewhat taller firebox; a drawing of one of those sent to England in 1839 "England" is thus shown in Whishaw 1840 and the drawing being contemporary is likely to be correct; see Figs. 7 and 8. As before mentioned, the inside fireboxes were of iron.

Puzzling discrepancies between the recorded length of boiler-barrel and that of the tubes—the latter in normal designs of the period being some 3″ longer than the barrel—in Norris engines of the same class, are evidently due to the employment of some kind of drumhead tube-plate at the smokebox-end. The plate of the Norris 4-4-0 "Patent" engine of 1843 (Fig. 10) shows one such case clearly.

All the early "true" Norris 4-2-0 engines are shown to have had the four-eccentric "drop-hook" valve-gear with a system of rollers mounted upon levers on the "reversing shaft" slung under the eccentric-rods and rockers, all the D-type "hooks" or slots being on the underside of the eccentric rods; other forms of the gear had the eccentric-rod ends slung from links depending from a reversing-shaft above. This drop-hook motion of course needed a connection to the valves for the purpose of moving same by hand into the required position when reversing—the vibrating-rod and hand-lever on one side can be plainly seen in all the illustrations—and thus there were levers—called in England "starting-handles"—on each side of the footplate oscillating

when the engine was in motion. About 1842 the "V"-hook came into use; this had what in England were called "gabs" or forks on the ends of the eccentric-rods and of course the angular lead-in surfaces of the gabs allowed the gab-pins and hence the valves, to be drawn into the correct position by the pressure exerted by the driver through the reversing-gear; the "V"-hook system generally had the gabs opposed for each pair of rods, but some arrangements had them on the underside of all four eccentric-rods.

In both systems of course the transmission of valve movements was generally by a rocking-shaft, upon the lower levers of which the rocker-pins (gab-pins in England) were mounted, and in both systems the opposite gear eccentric-rod end was maintained out of engagement by the same mechanism which kept the other rod connected. Shortly after this there was introduced the variable-cut-off gear which, by means of a separate valve placed directly on top of the full-stroke valve, enabled steam to be cut off at a definite point, generally about half-stroke. This auxiliary gear, which came into use with the V-hook gear, and of course only functioned in fore-gear, persisted for a good many years in America and this system—with variations in detail—continued until the merits of the link motion were fully accepted by U. S. builders about 1850. At first Norris operated this variable cut-off from the crosshead, but after only a few engines had been so built the system of obtaining the motion from an extra eccentric (one for each valve, of course) upon the driving axle was adopted by the firm. It is to be noted that the separate expansion-valve—working on the back of the main valve—had been the subject of a patent by Col. Long of December 1833.

The Norris write-up in U. S. Magazine of 1855 (20) states:—"In the 'George Washington' four eccentrics were used, and a throw given to the valve, which gave to the eccentric a cam motion, the 'ne plus ultra' of rapid movements. This has proved one of the most valuable improvements ever made in the construction of the locomotive." This of course must refer to the four-fixed-eccentric valve-gear (first introduced in England in 1835 by Hawthorns of Newcastle although James had apparently used it as early as 1829 in U. S. A.), but Long—and consequently the Norris firm—had evidently been using "four fixed cams" from 1834; the extant drawings of the true Norris show four-eccentric valve-gear with the downward-gab system—the drop-hook—and give no sign of any mysteriously effective "special cam" system. The provision of an extra amount of lead would not have helped because such is a disadvantage for slow hill-climbing, the steam ports however may have been larger than those generally used at the time although this normally would have little result at slow working speeds; however there seems little doubt that what McConnell stated in a discussion in 1843 viz. that the engines had very large ports and passages, was the good feature of their steam distribution, whilst the statement made in the same paper (14) regarding ¼ in. exhaust clearance is significant in regard to their heavy fuel consumption.

A characteristic feature of all the Norris engines of the period dealt with, was the slide-bar arrangement. In all the 4-2-0 engines and the

earliest 4-4-0's this was composed of two horizontally-disposed square bars, "placed diamond-fashion" to use an expression of the time. This same system was used by Hick in England on the three engines that firm built for the Birmingham & Gloucester Rly. but not by Nasmyth's in their six engines for that railway; it was also employed by Haswell of Vienna on his earliest Norris pattern 4-2-0's and also on a few of his earliest 4-4-0's. About 1845 Norris adopted an entirely different system; this comprised two round bars disposed vertically (see Fig. 12) but it is to be noted that the firm did not use this on any of its 4-2-0 or 4-4-0 type engines exported to Europe of which drawings or photographs exist showing their original condition, as the horizontal disposition "diamond fashion" was continued for the former whilst in the case of the latter, after keeping to the same arrangement until about 1842 it was modified in some cases by the substitution of square bars placed "square fashion" and of round instead of square bars but still disposed horizontally. None of the four arrangements appears on the few (4-2-0) engines the firm actually built in Austria.

Although the pair of vertically-disposed bars was taken up by Norris about 1845 the system appears to have originated with the Garrett & Eastwick (Harrison) engines, commencing with their "Hercules" of 1837; although it is not certain whether the slide-bars were of round or square section (placed "square-fashion"). The original Norris "diamond-fashion" method had a "slipper and set-screw" adjustment by means of which wear could be taken up, and this was also the case with their vertically-disposed round-bars in which they followed the Eastwick & Harrison practice in which slippers were also employed.

The popularizing of the vertically-disposed round bars, in which however an entirely different method of adjustment was employed, dates from about 1845-8, in the earlier years of which Haswell and other Austrian firms adopted it on locomotives built on the Norris principle, whilst in U. S. A. James Millholland, Master Mechanic of the Phila. & Reading R. R. from 1848 standardized its use on that railway. The round-bar arrangement was of course difficult to adjust for wear and in these designs of Millholland and the Austrian firms there was a "packing gland"—or "stuffing-box"—arrangement by which the cross-head sleeves could be made to increase their grip upon the slide-bars.

The arrangement looks poor, and Caruthers refers to tales of the "stuffing-boxes" being packed on occasion with various extraneous, non-metallic such as hemp and leather! Undoubtedly it was one of those features whose only advantage was its cheapness in first cost. Nevertheless Millholland continued it on the Phila. & Reading R. R. coal-traffic engines well into the 1860's, and shunting engines on that line were built with it as late as 1879, whilst it was much used in Austria, as besides Haswell, Gunther of Wiener Neustadt was occasionally using it until well into the 1850's.

The Norris firm themselves dropped vertically-disposed round bars (having the more adequate adjustment) about 1849, because by 1850, as is known from the 4-4-0 "Copiapó" built by them in that year and still existing in Chile, a form of two horizontally-disposed square bars placed "square-fashion" was in use.

All the Norris bogies were of bar-framed construction and their general features will be apparent from the various illustrations. In the 4-2-0 engines the bogie pivot was not in the centre of the wheelbase but 4" in front of it and the weight was not taken on the pivot but directly—at the side—upon the springs by means of an upward prolongation of the spring-buckle which passed through the bogie-frame and made sliding contact with the under-surface of a supplementary piece of the main framing; thus no weight at all was transmitted to any part of the bogie framing. Further although the pivot-pin was off centre, the weight was carried midway between the bogie wheelbase upon each side of the engine upon the "foot" of the inverted side-springs as stated; this was an important consideration as counteracting the tendency to "shoulder" which otherwise would have been very pronounced at the front of these engines.

This Norris caster-centre bogie evidently did not meet with the approval of the English or European builders, the only engines by such builders equipped with it being the first production and a few sister engines of 1840-2 by Haswell in Vienna. Bar framing for the bogie did not survive either because already by 1842 Gunther of Wiener-Neustadt was using plate bogie-framing of the English pattern. Bar-pattern main framing however lasted until 1844-5 in Austrian productions. Hick of Bolton, England, in his engines for the Birmingham & Gloucester Rly., although retaining the bar framing, placed the pivot centrally, but he followed Norris in taking the weight upon the underside of the main framing midway between the bogie axles, undoubtedly the correct method for these engines. Norris, although employing the off-centre bogie for his earliest 4-4-0's, was using a central pivot for this type by 1843-4.

Respecting the principal dimensions of the 4-2-0 type, sparse particulars of such—mostly repetitions—are scattered piecemeal through many accounts and drawings, but the dimensions given in the 1841 Circular (Appendix 4), which were repeated in various publications—and various independent records accord with them—are the only sure guide. They do not, naturally, give a complete picture, for which reason a few additional particulars, some derived from internal analysis of the table and others from contemporary or relatively early official records, are given below.

The lengths of the tubes in the various classes were evidently 9 ft., 7 ft. 4½ in., 8 ft., and 7 ft. respectively and available records and scaled measurements from drawings show that these lengths of tubes corresponded to a boiler barrel length exactly the same as the tube-length with the exception of class "A" in which the barrel length was evidently 8 ft. for a 7 ft. 4½ ins. tube length. As previously mentioned the normal tube-plate produces a tube-length some 3 ins. longer than the boiler-barrel, hence it is evident that these boilers generally had the front (smokebox) tube-plate about 3 ins. inside the barrel except in class "A" where the inset of the tube-plate must have been very considerable. The diameter of the various boiler-barrels can be gauged from certain of the available drawings and the stated quantity of tubes,

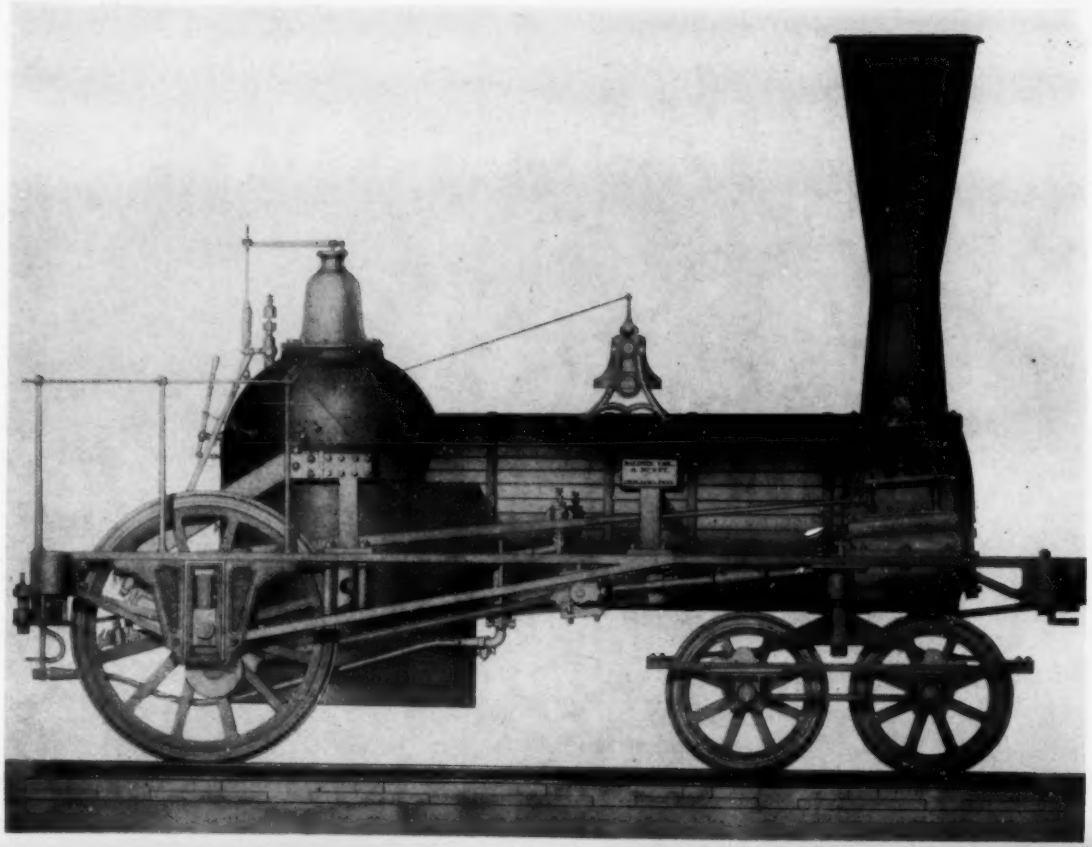


Figure 9

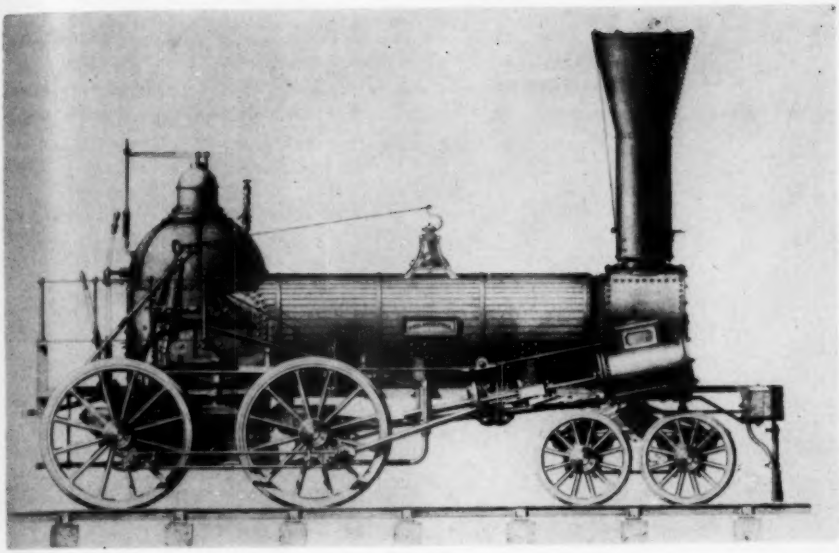


Figure 10

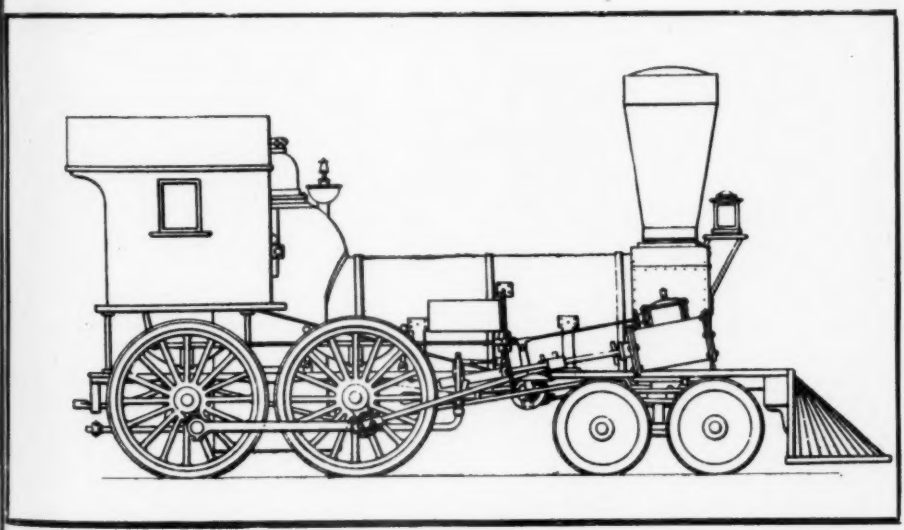


Figure 11

Figure 9

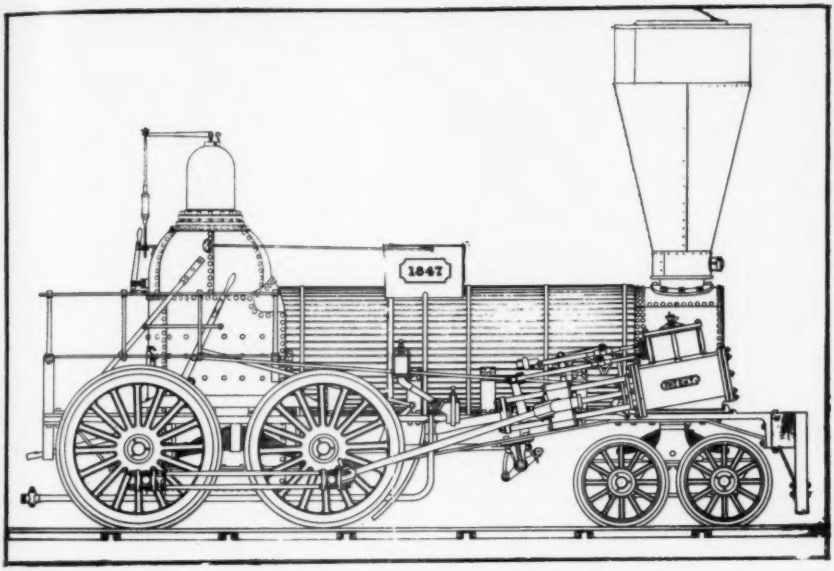


Figure 12

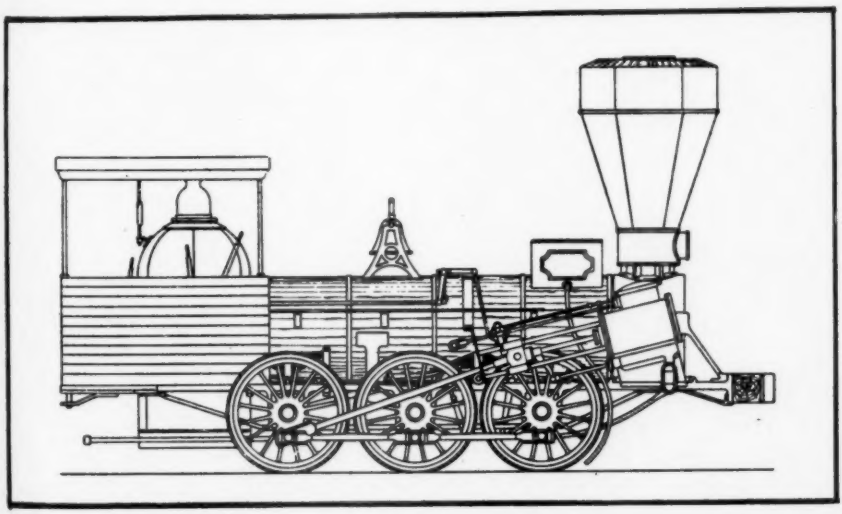


Figure 13

and the other principal boiler dimension viz.: the diameter of the firebox shell, can be derived from available sources and both these details are appended below the Norris table in Appendix 4.

Regarding the wheelbase, which evidently varied somewhat; in classes "A" and "B," the boiler barrel being the same length in each, the wheelbase of the bogie—the pivot being off centre as previously mentioned—was evidently 2 ft. 10 ins. to 3 ft. 10½ ins. whilst the total wheelbase was 9 ft. 5 ins. to 9 ft. 7 ins. Of the other classes, the only available record is of class "A Extra"—Clark 1855—and indicates a bogie wheelbase 2 ft. 11 ins. and a total wheelbase 10 ft. 5 ins. to 10 ft. 7 ins. No record is available for class "C," but as class "A Extra" differs exactly in accord with the increased length of barrel probably class "C" accorded with the 1 ft. lesser length of barrel i.e. a total wheelbase around 8 ft. 7 ins. The weight of the class "A Extra," as will be seen below, was very little less than the lightest of the 4-4-0's.

A full treatment of the dimensions of the Norris 4-4-0 type is unnecessary, as the size and details of this type quickly developed beyond the firm's standard dimensions; their standard engines had cylinders between 10½x18 and 12½x20, driving wheels of various diameters from 4 ft. to 5 ft.—but mostly 4 ft.; bogie wheels generally 2 ft. 6 ins. diameter ("outsize" engines had cylinders varying from 13x20 to as much as 15x22 and 14x26 with drivers 4 ft. 6 ins. and 5 ft). The wheelbase varied considerably, in accordance with the cylinder sizes etc. and has no interest here. Their weights in working order varied from 30,500 lbs. in the earliest, to 38,000 lbs. by 1848, the proportion of weight available for adhesion being generally 55 to 65%.

SOME OTHER NORRIS PRODUCTIONS FOR THE U. S. A.

Having dealt with the classic Norris designs in America, brief mention should be made of a 0-6-0 type; this was brought to attention in an article by C. H. Carruthers in 1899 (33) who in describing the engine—his drawing is shown here in Fig. 13—ascribes it to Norris 1844 named "Richmond," mentioning its early explosion and rebuilding by the Phila. & Reading R. R. as "Philadelphia." It certainly was a Phila. & Reading R. R. engine and is also attributed by Jahn 1924 (44) to Norris 1844, but in Sinclair 1903-5 and 1907 (34) and (R. I. 16) what is clearly the same engine (or design) with some slight changes to the boiler-mountings, is shown and is there attributed to Millholland about 1849. As it exploded soon after being built, Sinclair's date of 1849 seems too late and it has also to be remembered that Millholland, to whom he ascribes the engine, did not become Master Mechanic of the Phila. & Reading until 1848.

The design might well have been a Norris, the firebox being typical and the method of connecting the rear ends of the slide-bars with the boiler is "Norris"; there is also a most unusual feature in the placing of the pumps forward under the cylinder-barrels. This unusual arrangement of the pumps was carried out also on Norris's 4-6-0 design of 1846, though whether this arose from Norris or was due to the rail-

road I must leave our U. S. A. members to decide. The idea of a pump alongside the cylinders appears first on Eastwick & Harrison's "Gowen & Marx" of 1839—but in that case the pump-barrel seems to have been tucked away between the cylinders and the smokebox.

It is to be noted that the boiler and wheels of the 0-6-0 lend themselves to the evolution of the immediately succeeding 4-6-0 design; in fact the family resemblance is so strong that it must be concluded either that Norris designed both types or that he copied much Millholland detail in his 4-6-0; the author believes the former. As the boiler of the 0-6-0 exploded within a year of delivery, the drawing given by Sinclair may represent the engine with its new—Millholland?—boiler, particularly as it shows a most un-Norris small dome near the smokebox, although the Caruther-Jahn drawing shows a primitive cab and hence would seem later.

This 0-6-0 design had no effect on U. S. practice and its interest here is that—if it was a Norris—it seems to exhibit the earliest use by the firm of the two-round-bars-in-vertical-order pattern of slide-bars. This was the pattern adopted by Millholland and used on the Phila. & Reading for many years and, as will be seen in the later portion of this account, was that used in many of the Austrian-built and other derivatives from Norris types; Millholland and the Austrian firms, however, used the system of "packing-glands" to take up wear, whilst Norris used the more normal system of adjustable slippers in which he followed the originators of the vertical two-bar system, Eastwick & Harrison. The dimensions of the 0-6-0 are stated as Cyls. 15 ins. x 20 ins., Whls. 3 ft. 8 ins. and it was of course "ipso facto" a long-boiler type, though whether influenced by the English long-boiler fashion of 1842 is not determinable.

The 4-6-0 had Cyls. 14½x22 ins., Drivers 3 ft. 10 ins., and weighed about 44,000 lbs. in working order; this was the "Chesapeake," the first of the 4-6-0 type, being built for the Phila. & Reading R. R. under some patent of—and almost certainly designed by—Septimus Norris, and placed in service early in 1847; in this particular Norris design the bogie carried very little of the weight of the engine. The type soon became popular in U. S. and was built in ever increasing numbers by almost all American builders. In 1849 a 4-4-0 having 8 ft. 0 in. drivers is stated by Caruthers (37) and other authorities to have been built by Norris for the Erie R. R. having the cylinders to the rear of the smokebox with the drive on to the rear pair of coupled wheels; no other particulars of the engine are available but it is mentioned here as an innovation in the Norris sequence of design and which apparently was not repeated. It may fittingly close the account of the principal Norris designs up to 1848 for use in U. S. A. Caruthers' articles of 1909 already referred to contain many illustrations of further developments in Norris design. There was also a Norris engine—on the Philadelphia, Wilmington & Baltimore R. R. just prior to 1849 and named "Washington"—having three cylinders, two outside and one inside; the engine weighed 49,000 lbs. and so was near the maximum size of the time, but its type seems unknown. As by 1855, however, there was another three-cylinder

engine on the P. W. & B. R. R. rebuilt by the railroad from a Norris, it is probable that both were so rebuilt; these must be the earliest three-cylinder locomotives in the U. S. and details of these engines would be of great interest.

THE VOGUE OF THE NORRIS "STANDARD" LOCOMOTIVES IN THE U. S. A.

Before concluding this portion of the account, a brief indication may be given of the vogue of the Norris 4-2-0 and 4-4-0 types in U. S. A., limiting this in the case of the latter type to engines which were fully "makers designs"—the 4-2-0 were almost all so; reference is therefore made to certain published statements regarding quantities of locomotives built by the firm up to 1858 viz.: 1838 (5), January 1841, April 1841, 1844, 1852, 1855 and 1858; the details of those for 1841 and 1844 being given in Appendices 5 and 6. In the six latter authorities exported locomotives appear and these will be dealt with in the subsequent part.

Up to October 1836, the time when the "Washington County Farmer" was completed, 12 or 13 pre-"W.C.F." locomotives were built (including the three anthracite-burning engines of 1833 to the Boston & Providence R. R.) of which possibly 3 were almost certainly of "George Washington" pattern, including the "G.W." itself. From thence up to October 1838 there were (vide Congress Doc. 21) some 29 engines constructed (plus 3 apparently omitted from the returns) which it can be assumed were all 4-2-0 "W.C.F." pattern; in addition to which about 5 of the same pattern were exported. The total constructed up to Oct. 1838 was apparently therefore 49 of which 6 of the earliest engines had by that date gone out of use or found their way on to lines not included in the Govt. Returns.

Norris's list of January 1st, 1841, see Appendix 5, (its text shows a total of 135 locomotives, whereas the list actually contains 138 and includes some "export" engines not delivered for many months after) shows 97 locomotives for U. S. A. and 8 for Canada and Cuba, whilst there are 33 for England and Europe; it is unfortunately not possible to be definite as to how many of these locomotives were 4-4-0 engines, as this type had been built by Norris from late 1839 and it is known that some of those to Cuba (but none to England or Europe at that time) were of this type, but it is unlikely that there were more than a dozen 4-4-0's. Of course the list must include the various pre-"true" Norris, which as already indicated will have totalled some 12 or 13, thus leaving about 114 4-2-0 "W.C.F." pattern built. Of the 39 4-2-0's exported, practically all can be traced, but of about 75 built for U. S. A. the author has only been able to trace some 46; there is thus considerable scope for U. S. members who may be interested.

The statement of April 1841—see Appendix 6—seems to show 104 engines for U. S. A. and 38 for export; it incidentally proves that some of the engines shown in the January 1841 list as exports had not in fact then been delivered.

In an 1844 account of French industry there is a brief list—see also Appendix 6—from which it is seen that the total of Norris engines built for the Western hemisphere had then reached 135, whilst exports to England figure as 15 and to the European continent 82, a total of 232. This list presents some problems because although the quantities indicated for Austria, Prussia and France are about correct—there is an error in showing 15 instead of 17 to England—the large quantity of 19 set out as having been exported to Belgium, Italy and Wurtemberg cannot be accounted for. These matters however are considered in the subsequent account of the exports to Europe.

The next published figure of output is that appearing in the preface to a somewhat rare book of 1852 by Septimus Norris (19) in which the quantity, 170, stated to have been exported to Europe must be erroneous, which matter will also be dealt with further on, but the total quantity of locomotives, "some 530 locomotives" is no doubt correct, as during the year 1850 it is known the firm turned out their 420th locomotive and by 1853 had reached 649. In the inspired "write-up" of 1855 the total is given as 806 including "117 on foreign account"; whilst in an account (22) of 1858 it is stated that 937 locomotives had then been built, of which "156 were for foreign lands." Discordance regarding the quantity of locomotives exported is apparent between the accounts of 1852, 1855 and 1858, and this is dealt with in the subsequent account also.

It has already been mentioned that up to the time of compiling the U. S. Congress Doc. 21—October 1838—there had been about 32 4-2-0 true Norris engines constructed for U. S. A.—excluding some 5 to Europe, Canada and Cuba. In all there appear to have been some 90 4-2-0, and 60 4-4-0—plus 10 uncertain of which type—say 160 in all, upon some 24 different U. S. lines, from the "W.C.F." of Oct. 1836 to the end of 1848; this is exclusive of large "out-size" 4-4-0's which were built on an increasing scale from about 1845-6, as also a few large 4-2-0's specially designed for particular railways, and of locomotives of other types. On the American lines the 4-2-0 appear to have been mostly class "B"; there were a few "C," less of class "A" and less still of "A Extra" which was supplanted almost contemporaneously by the introduction of the 4-4-0 pattern.

Most of the 4-2-0's had gone out of use by 1857, but one of them—the "Wm. Penn" already mentioned (R. I. 2), which however was a pre-"G.W."—much rebuilt—was in existence as late as 1898. As will be seen in the account to follow, the year 1857 represents the limit of railway life of Norris locomotives exported to England whilst most of those sent to Europe had also disappeared by that time. The 4-4-0's naturally lasted longer than the 4-2-0's—both in U. S. A. and in Europe—and although individual cases of perpetuation by drastic rebuilding are known, it is believed the average life of the Norris 4-4-0 in U. S. A. was rather less than contemporary 4-4-0's by other makers.

Norris Locomotives in Europe

THE EXPORTS FROM U. S. A. AND THEIR EUROPEAN SUCCESSORS

With Addenda for Canada, Cuba, and Chile

PART II

PRELIMINARY, AS TO QUANTITIES EXPORTED

There has always been obscurity regarding the number of Norris engines built by the firm for Europe, the prime difficulty being that Septimus Norris, in his preface to his own book of 1852 (19) says "In connection with my brothers, I have constructed and built some five hundred and thirty locomotives; one hundred and seventy of which are now successfully running on roads in England and the Continent, seventeen of which are running on the Birmingham and Gloucester Railway, England." The 17 to B. & G. can be accounted for, but even including the six engines built by the Norris Works at Wien—which must be considered included from the particular form of words used by Norris—and allowing for some 10 still untraced engines probably in Italy, the author has been unable to account for more than 109. On other grounds also the figure 170 is incredible and has been hazarded to include Norris-type engines built by other firms in Europe, but the wording precludes this solution and if the latter be included the total would be far greater than 170.

However it seems possible to resolve this problem as follows. In the write-up of the Norris Works in 1855 (20) it is stated that up to October 1855 the firm had built 806 locomotives "of which 117 were for Foreign account." This immediately destroys the 170 legend and not only so, but "on foreign account" is stated to include all exports, and reference to the particulars given by the firm to the American Railroad Journal April 1841 (see Appendix 6) shows that at that time there were 13 built or building for Cuba and at least one was built for Chile in 1850, which, therefore must be allowed for. Deducting these from 117 the figure 103 is obtained for the European exports which, omitting the 6 built at Wien as excluded by the wording of the 1855 write-up (but included in the 1852 statement), compares with the 93 certain to Europe plus 10 (doubtful, to Italy), which the author has been able to trace. We are thus driven to conclude that Norris's preface said one hundred and seventy in mistake for one hundred and seventeen (did they have shorthand clerks in those days). It may be added that a publication by Freedley, 1858 (22) states that up to 1858 the firm had built 156 locomotives "for foreign lands" and it would seem this must include engines built for Canada and Cuba—and other countries?—beyond those traced by the author as set out further on, because there is a shortage of some 20 locomotives in order to reach a total of 156. In any case the possibility that the 117 statement of 1855 was an error for 170 and that of S. Norris of 1852 was after all correct, is also rendered untenable by Freedley's account.

Up to 1838 inclusive there had been two 4-2-0 type exported to Europe by Norris—to Austria—whilst by January 1841 (see Appendix 5) the quantity exported had reached 15 to England and 18 to the European Continent respectively; from another statement of the firm three months later (Appendix 6) the exports to England had reached 16 and those to the Continent 14 but with 12 "yet to go," making 42. No further detailed lists by the firm are known to the author and thus recourse must be had to scattered records in the importing Countries.

From diverse sources have been compiled lists of all Philadelphia-built Norris engines traceable in Europe, those for the European Continent being given in Appendix 7. No explanatory comment is made on them here—reference to totals has been made above—but the details are progressively reviewed in the respective sections following. The totals are: to England undoubtedly 17, to the Continent 76, plus probably 10 untraced, making in all some 103.

Very large quantities of Norris-type locomotives, both 4-2-0 and 4-4-0 were built on the Continent—besides a few of the former built in England—and their evolution from the original Norris pattern is so considerable as to make any separate summary of the total quantity of the 4-4-0 type pointless; this aspect being contemplated to as late a date as is necessary in the progressive description of the latter pattern as design developed. Contrary to what is often supposed, viz, that the Norris exports were to England in the first place, the first Norris 4-2-0 went to Austria at the end of 1837, and it was not until the beginning of 1839, by which time two more Norris engines had been exported to the European Continent, that the first locomotive was shipped to England in February 1839.

MODELS OF 4-2-0 TYPE LOCOMOTIVES SENT BY NORRIS TO EUROPE

Before dealing with the Norris engines to the European Continent, mention should be made of the series of reduced-scale locomotives—or "Models"—although these were not made until some years subsequent to the first exports.

In 1842 Norris made three small-size—variously stated to have been 1/3 and 1/4 size—but very exact working copies of his class "B" engines, these being sent to the Sovereigns of Austria, France and Russia. These models are mentioned in various accounts in different countries and Golsdorf (32) makes an illuminating remark that "from Russia he [Norris] only received thanks, from France he received orders"—but only for one engine!—"whilst in Austria he was granted permission to build Workshops for the construction of locomotives." Further, a U. S. A. report of 1843 (12) stated "the French King has presented Mr. Norris with a gold box ornamented with diamonds, besides giving him an order for several locomotives"; adding in March 1843, "Mr. Norris has been very successful with his miniature engine in France"; nevertheless as will be seen there is record only of one Norris-built locomotive working in France.

The working model sent to France had cylinders 3⅛ in. by 5 in. and it hauled a carriage seating 10 persons upon a specially-laid track (perhaps at the Museé de Marine) and, according to another U. S. A. report of 1843 (13) "his Majesty was pleased." However the only locomotive built by Norris traceable as having worked on the French railways is one built in 1843 for the Montepelier-Nimes Rly. The model sent to France was given by Louis Philippe to the Louvre Museum in 1846 and was eventually transferred to the "Conservatoire des Arts et Metiers," Paris. Working model locomotives of this size are unusual and therefore it is illustrated here in Fig. 14. It may be added that there is a small-scale model—stated to have been made in 1843 to represent an engine built for Austria in 1838—of a Norris 4-2-0 locomotive in the Science Museum, South Kensington, London; this bears the name "Austria" but does not exactly represent any locomotive built for that country, although it has greatest affinity to some Norris-pattern engines built by Hick & Son of Bolton, England; it is possible it originated from one or the other of the series of locomotives built in England for Austria but the Author is not able to recognize it as an exact replica of any such.

NORRIS LOCOMOTIVES IN ENGLAND

The importation of Norris locomotives was by arrangement with the Birmingham & Gloucester Rly., a railway having a very steep gradient—of 1 in 37½ for 2⅛ miles upon the main line—and where undoubtedly the accounts of the hill-climbing feats upon the inclined plane near Philadelphia had great influence, but where nevertheless the Norris locomotives were not employed solely upon the particular work of their "Lickey" incline. Doubts and discussions—in and out of print—as to (a) why these engines were imported by the Birmingham & Gloucester Rly., (b) what they actually accomplished in the service of that railway and (c) why the importations of such locomotives were discontinued, have continued to engage the attention of railwaymen in England and—it is believed—in U. S. down to recent times. The controversy is one particularly pertaining to English locomotive history and the matter has been dealt with by the present writer—who fortunately was able to consult the original contemporary documents of the railway concerned—in a Paper before the Newcomen Society of England in 1947. Much erroneous information and incorrect "facts" have been current, but briefly the case was that the earlier—small—engines failed to fulfill the stipulated conditions but in the end there were five of the larger (Class "A Extra") which were able to handle trains on the gradient satisfactorily.

The total quantity of locomotives supplied by the Norris brothers to England has been a matter of doubt for a hundred years, but it can be definitely deduced from contemporary records that this total was 17—thus confirming Septimus Norris. There were seven engines of class B, three engines of class A, and five engines of class "A Extra" supplied directly by Norris Bros. plus two of class B which the Birmingham & Gloucester Rly. purchased through a firm Messrs. Banks of Manchester,

England. The first engine, which was a class B, was shipped from the U. S. A. on February 19th-1839 (not in 1838 as erroneously appears in some U. S. publications of much later date), the others following at fairly frequent intervals until the early part of 1841, when the total was 15 Norris Philadelphia-built engines; later on, early in 1842, two further engines were received from U. S. A. From the commencement it was clear that class B engines were insufficiently powerful for the incline work and class A engines also proved insufficient, hence the banking work fell to be carried out by Norris class "A Extra" engines —which were altered to saddle-tanks quite early—whilst the before-mentioned classes took up ordinary duties, the class A particularly being used for passenger work for some time. However these engines, with the exception of those used on the incline, had all been substituted by 1844-5 and they were all, including the incline engines, sold or broken up by the railway—the Midland Rly., which absorbed the B. & G. in 1847—by 1857, two having been sold as early as 1844, and 10 more by 1849.

The introduction of the Norris engines into England led to a few of the same pattern being built by firms there, 9 being supplied to the Birmingham and Gloucester Rly. of England and some 4—perhaps 5—in all, by English firms to the European Continent. There were no Norris 4-4-0 engines exported to England nor any built there of the Norris pattern and neither the 4-2-0 nor 4-4-0 had any influence upon locomotive design in that Country; upon the Continent, however, in Austria and Germany the influence of the Norris pattern was considerable. The three sizes of Norris engines used in England are represented in Figs. 3, 5 and 8 in the previous U. S. A. section.

4-2-0 TYPE LOCOMOTIVE EXPORTED BY NORRIS TO AUSTRIA AND GERMANY

Although the first locomotives in Central Europe were imported from England, the Norris type was considered by Austrian authorities to have had advantages for conditions in that country; better adapted for sharp curves and inferior track and with simplicity of construction—especially the absence of crank-axles, very difficult to produce at that time—so that it was easier to copy the Norris pattern. Although the exports to Austria and Germany of Philadelphia-built 4-2-0 and 4-4-0 types combined were more or less equal in number, the derivations from both types were much more strongly represented in Austria than in Germany. After the early period of the 4-2-0's, the 4-4-0 design with outside cylinders—either normal or what was practically the "long-boiler" pattern—came to be called the Norris type in Europe no matter how much the later European-built engines advanced; although, as previously pointed out, the general 4-4-0 design was more attributable to Eastwick & Harrison than to Norris.

It should be stated that the particulars of the engines in Austria and Germany owe much to accounts published during 1898-1930 by Golsdorf (32), Littrow (41), Hilscher (42), Helmholtz (46) and others,

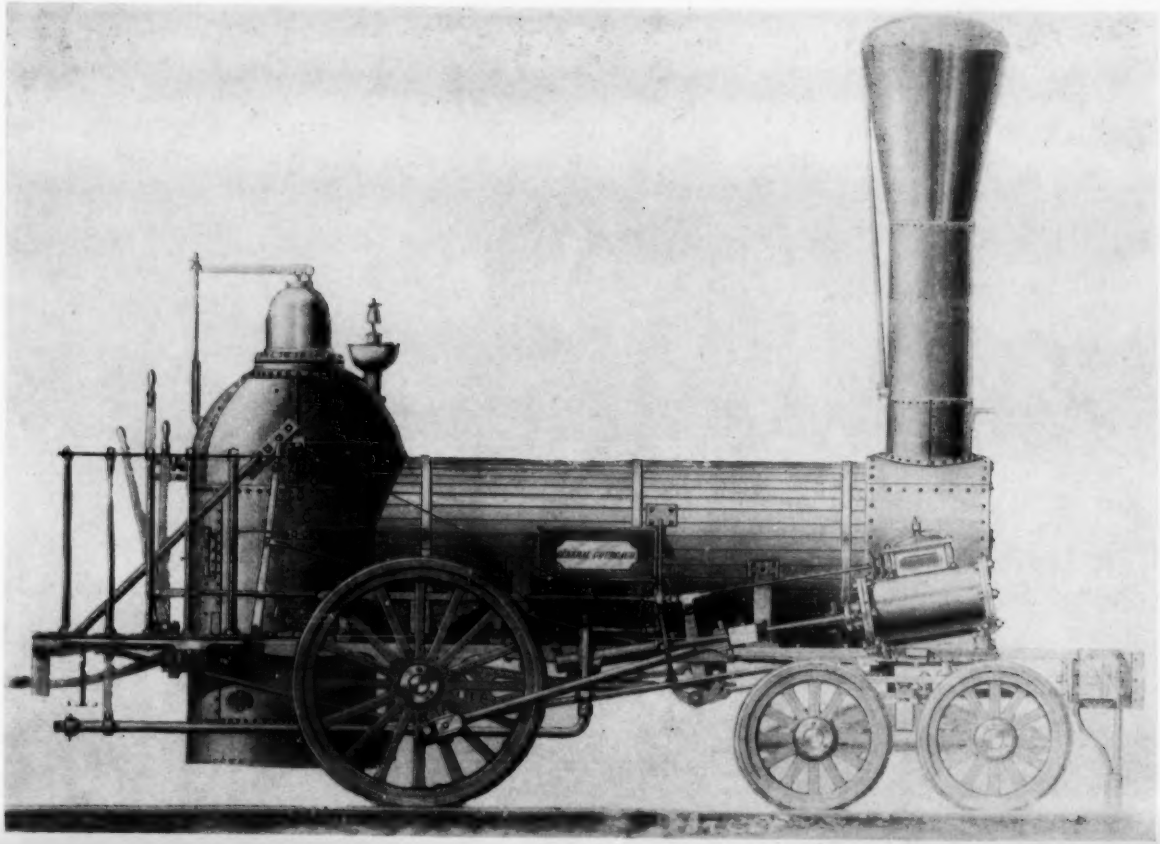


Figure 14

2 A. Bauart Norris 1839.

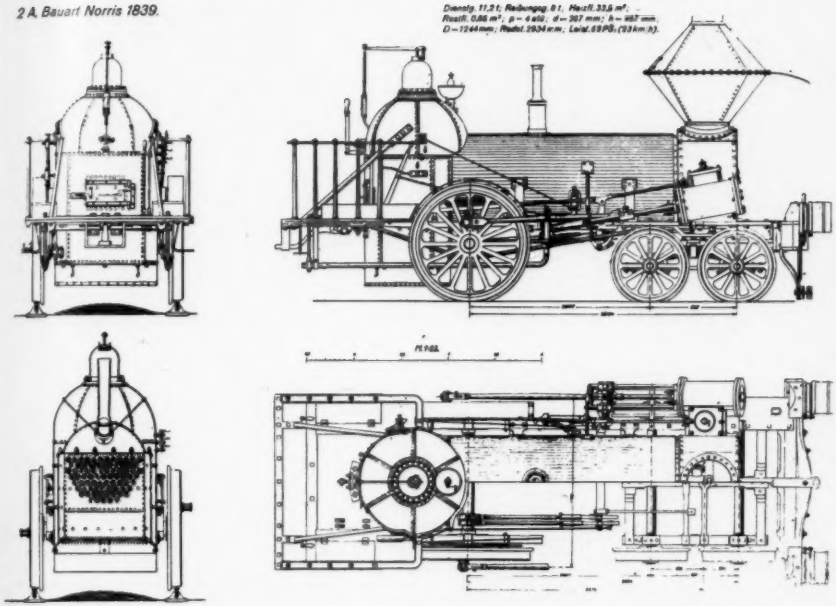


Figure 15

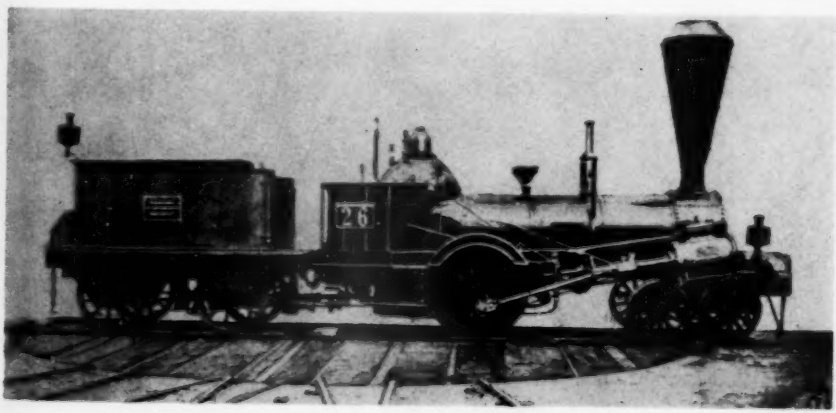


Figure 16

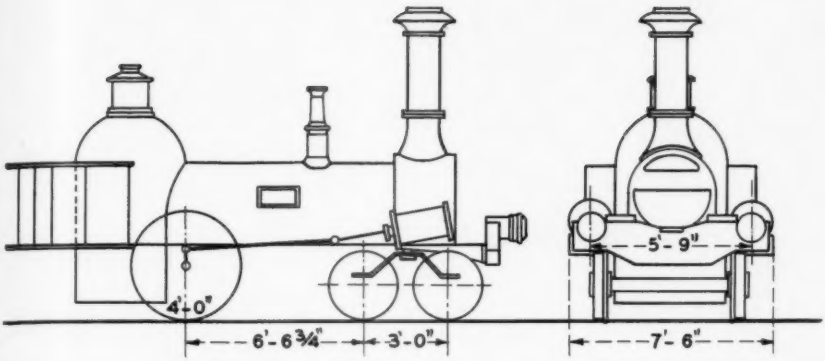


Figure 17

Figure 18

and to pre-war communications from those countries, whilst in respect to France, Belgium and Italy communications from Messrs. F. Achard, A. Jacquet, C. H. Dickson and the Italian State Rlys. respectively have added valuable data. Nevertheless it is necessary to lament the lack of certainty in respect to further engines certainly supplied to Italy and to possible additional engines for Switzerland; this being due to some investigations into the ultimate obscure points, becoming cut short by the war and the sources being now unavailable.

It has been found preferable to treat the Norris locomotives on the Continent in separate sections, viz.:—the Norris 4-2-0 type engines exported from Philadelphia, definitely following an identical design and differing only in size—according to the established Norris classification —and so conveniently dealt with chronologically with deliveries to Austria and Germany grouped together; followed by the 4-2-0 locomotives built by Norris in Austria; and then by those of 4-2-0 Norris-type built in Central Europe as derivatives from the Norris pattern also grouped together. In the case of the 4-4-0 Norris type, of which such varied designs and large quantities were built in Europe in addition to a fair number built in Philadelphia for the Continent, the same treatment has been adopted. In respect to the Norris locomotives of both 4-2-0 and 4-4-0 types in Belgium, France, Italy and Switzerland and including both Philadelphian and European build, the limited quantities of locomotives concerned makes it practicable to deal with them combined under their respective countries of use. A list showing in chronological order the whole of Norris supplies to the Continent both of the 4-2-0 and 4-4-0 types—complete so far as the author's data will allow—are given in Appendix 7. The large number of European-built derivatives are not listed however as that is a matter of general Continental locomotive history.

There is no doubt that the first locomotive exported from America to Europe was the "Philadelphia" finished in November 1837 and arrived in April 1838 having been shipped to Trieste (then in the Austrian Empire). The engine had been purchased for the Wien-Raab Rly. on the recommendation of M. Schonerer who was "director" of that railway, who had seen Norris locomotives on a visit to America. It may be mentioned that this locomotive, from its being exhibited running in steam near the present Philadelphia Bridge at Vienna after the opening of the Wien-Gloggnitz Rly. gave its name to the bridge, being probably the only—possibly unique—case of an important bridge being named after a locomotive. Austrian records show the engine to have had Cyls. 10½x18, Drs. 4/0, weight in working order 10¾ tons; hence it was a Class "B" engine.

Following the "Philadelphia" some time during 1838 was the "Columbus," a class "B," to the Kaiser Ferdinands Nordbahn. Then from late 1838 and during 1839 were delivered two more engines—"Laxenburg" and "Baden"—to the Gloggnitz line; one—named "Baltimore"—to the Brunswick Rly. and two to the Berlin-Potsdam Rly.—named "America" and "Prussia." One of the three to Germany probably that to the Brunswick line, was the first Norris to that country

whilst "America" carried the earliest Norris makers-number known to the author—No. 79. All these engines, with the exception of "Laxenburg" the dimensions of which are unrecorded, are known to have been Class "B" and a very complete drawing from Helmholtz 1930 (46) believed to represent the actual engines to the Berlin-Potsdam Rly. is given in Fig. 15. Being the standard Norris of the time and fully described previously, the only points here requiring attention are that the firebox is of the true "Bury" pattern, that there were no roof-stays between the firebox crown and the domed top of the firebox shell, the crown being supported solely by longitudinal crown bars seating fore and aft upon the firebox itself and the domed top being apparently without stay support of any kind; that there is a lock-up safety-valve—possibly added in Germany—and that the "adhesion inducing" form of drawbar is more accentuated than ever. There is also the peculiar form of spark-arresting stack with the netting placed near the bottom instead of the usual position near the top; this arrangement—also adopted on certain locomotives on U. S. lines—allowed the chimney to be hinged just above the "diamond" portion and lowered in the manner of river steamers passing under bridges; in order to forestall enquiries as to the "raison d'être" of the "tail" in front it may be explained that—the netting of course being fixed at the junction of the two conical portions —this "striking-plate" when hit with a hammer helped to clear a clogged netting by transmitted vibration; a small door was, as shown, also provided to help clear a choked netting.

Reference to these early Norris engines to Germany is made in a contemporary German publication of 1842 (11) where in remarks concerning the Dusseldorf-Elberfeld Rly.—for which a "Norris" locomotive was built in Germany in that year—it is stated "There is not a better engine than the Norris locomotive for a railway with steep gradients and sharp curves. The boiler—produces a large amount of steam and at low speeds. Two-thirds of the total weight are upon the driving wheels—it is possible to load them with [part of] the weight of the tender." In the same publication (but not representing the German-built engine) is a drawing, most probably showing one of the engines to Germany, from which will be seen another example of the curious form of spark-arrester on the chimney-top; there was apparently an arrangement by which a central section could be raised—presumably when steaming was bad and/or there was little danger of producing lineside fires. The spark-arrester upon the engine of the Austrian lithograph referred to above, although poorly delineated was evidently also of this pattern.

After the above seven deliveries there was a pause until 1841, the intervening period coinciding with the major part of the Norris deliveries to England as already referred to. It may be interpolated here that the first Baldwin locomotive to Europe was delivered during 1841, to the K. F. N.; it was a 4-2-0 with Cyls. 13x18, Drs. 4/5 and evidently of the Baldwin standard pattern of the time.

The year 1841 saw the commencement of a long "run" of 15 engines to the Berlin-Frankfort Rly. Four in 1841, first one named "Berlin," and 5 in 1842 being class "B" engines, whilst 7 others—first one named "Concordia" in 1842 and a further one early in 1843, had Cyls. 12½x20,

Drs. 4/0 and hence were either class "A" or class "A Extra." Also in 1841 the Berlin-Stettin Rly. received two class "B" engines—three were shipped but one was lost at sea—one being named "Oder," whilst the K. F. N. received three engines, the first named "New York"; these were 12½x20 cylinder engines but are known to have had class "A" boilers—i.e. 8 ft. barrels—and this circumstance may also apply to the 12½x20 engines of the Berlin-Frankfort.

Finally in 1843, one locomotive "Rubezahl" was delivered to the Breslau-Schweidnitz Rly. having Cyls. 11½x20, Drs. 4/0 evidently a normal class "A" engine. German records show the boiler-pressure as 57 lbs. which contrasts with the 80 to 90 lbs. pressure which is generally attributed to the Norris-built engines of the 1844-6 period.

So far, with the exception of the class "B" engines to Germany and another of the same class shown later, representations of the individual engines fail us, although the general appearance of the different classes can be deduced from illustrations previously given. The principal lacunae arising from this lack of illustrations is the impossibility of tracing, upon the imported locomotives, the development of the firebox away from the initial "Bury" form, partially elucidated previously amongst the U. S. prototypes.

In respect to the last set of 4-2-0 engines built in Philadelphia for Central Europe however, a photograph of one of them exists. These engines were a set of four delivered to the Austrian Northern (State) Rly. in 1844, one of which, named "Eger," is shown in Fig. 16, Cyls. 12½x20, Drs. 4/1½, Boiler Press. 80 lbs. Here we have a *full* Class "A Extra" with all the typical Norris features, and it is doubly interesting as the only example showing the constructional features of that class and so probably corresponds in many respects to the "Philadelphia" and others of class "A Extra" supplied to the Birmingham & Gloucester Rly. of England. It is to be noted that the firebox is of the "B"—or intermediate—pattern and thus agrees with the rough diagram (Fig. 3) of the latter engines given by Clark 1855, it is also noticeable that although the drop-hook valve-gear is retained, the motion-plate is not connected to the boiler but follows the arrangement appearing on the 4-4-0 "Patent Philadelphia 1843." (Fig. 10).

With these engines terminates the Norris Philadelphia supplies of 4-2-0 engines to Europe—11 to Austria and 22 to Germany (including one lost at sea), with the exception of two single cases in 1843-4 to France and to Belgium referred to further on.

Most of these 4-2-0 Norris-built engines lasted to around 1857-8 although a few of the earliest-built "went" as early as 1848-50 and some of the later ones were in railway service as late as 1862-3. Some of course finished their careers on lesser duties and an interesting case is a pair of those supplied in 1841 to the Berlin-Frankfurt Rly., these were Norris Nos. 131-2 and their final condition is shown in Fig. 17 when they were employed on service jobs—and burning peat—on the Oldenburg Rly. until finally scrapped about 1866. A photograph of the actual maker's plates from these two engines existed in Germany for many years and Fig. 18 is a reproduction therefrom. From an illus-

tration in a German official publication (R. I. 17) it is evident that, like the case of some of the Norris-locomotives on the Birm. & Gloucester Rly., a number of these Norris-pattern engines were later fitted with saddle-tanks.

4-2-0 TYPE LOCOMOTIVES BUILT BY NORRIS AT VIENNA (WIEN)

Mention has previously been made that William and Octavius Norris went to Austria in the autumn of 1844 and from a contemporary U. S. A. newspaper of that year (15) we read that a dinner was given on August 28th to W. Norris "previous to his departure to supervise the building of locomotives in Vienna for the Austrian Railways" and that "he had concluded very large and important contracts for the introduction of his locomotives on the railroads of Austria and other countries." As it is clear W. Norris—and presumably his brother—arrived in Austria towards the end of 1844 and W. Norris returned to America in 1848, it is evident that although according to—apparently inspired—statements, the venture was highly successful, the Norris's work there was confined within four years and was much less than commonly supposed. The Works were in the Wahringer Strasse on a site which was at the rear of what later became the locomotive building works of G. Sigl, who later also assimilated the Norris property.

In the past there has been some confusion regarding certain sets of "Norris" engines of 1843-6 in Austria, as to whether they were built at the firm's Works in Wien or in Philadelphia—in fact Austrian writers give a variety of dates for certain sets of engines built in those two places during the period 1842-46, even disagreeing amongst themselves in some cases as to the Works, whilst in some cases Philadelphia construction appears in a list whilst Wien is attached to an illustration of the same series of engines in the same article! However it is possible to clear up the discrepancies by collating certain known Works numbers of Norris engines in Europe, and by a close scrutiny of constructional details.

The Wahringer Strasse works must have been begun during 1845 and it is clear that the first engine was completed there in 1846, and this engine and its two sisters appear in all Austrian accounts as having had Works Nos. 1 to 3; they were followed in 1846-7 by another series of three practically identical engines, the third being dated 1847 and these are regarded as corresponding to Works Nos. 4 to 6. During these years there were 24 other Norris-built engines put into service in Austria and Hungary of which all are stated in one account or another to have been built in Wien. The significant point about these 24 engines is that their Works numbers range correctly with those which records of other locomotives prove to have been current for the period in the Philadelphia Works. The "run" of these works-numbers will be apparent upon referring to Appendix 7, which also adduced a further indication viz.:—that a Works commencing early in 1845 is hardly likely to have had a production sequence of "nil," "29," and "one" in the three years 1845-6-7 respectively.

Of course it would have been possible for the firm to have allocated a batch of Works numbers—kept blank in the Philadelphia books for the purpose—to the Austrian Works and this might at first sight appear to be the explanation in view of the generally reputed successful output of the Norris Wien Works. However if it be assumed that these 24 engines—or even an appreciable portion of them—were constructed at Wien, then the quantity of locomotives mentioned in various contemporary statements regarding the Norris exports from U. S. to Austria would be too high. A further and important point is that the two sets of three 4-2-0 engines certainly built at Wien have many similarities with each other which are not characteristic of Norris Philadelphia design—being very like contemporary 4-2-0 locomotives by the Wiener Neustadt Works of Gunther—whilst the twenty-four 4-4-0 exhibit exclusive Philadelphia features. This reasoning is partly based on the extant photographs of the two Wien classes, admittedly taken a number of years after the construction of the engines, but conclusively confirmed by the recent discovery of a drawing reproduced in Fig. 19—which together with five others will be referred to here as the "Norris-Wien-drawings" and an extended notice given further on—evidently contemporaneous with the Norris operations at Vienna (Wien), which coincides in every way with the Wien series Nos. 1 to 3 with the exception that at the time of the photographs a dome had been added (in the position where originally was placed the safety-valve) on the boiler-barrel and a different chimney provided.

"Before leaving this drawing Fig. 19, attention should be directed to the form of the wheels, viz.: spokes and rim formed of "T-irons" bent and placed back-to-back and "cast-in" into the central boss—somewhat similar to the practice of certain English builders of the time—whereas the photographs (vide Figs. 20 and 21) show wheels of a different pattern; in this also there is significance because these latter wheels are of the peculiar staggered spokes and large boss pattern precisely the same as appear on the "Norris Wien drawings" for 4-4-0 engines shown in Fig. 29 further on. It will also be seen from Fig. 19 that the weight at the front end is transmitted from each main frame by means of a roller underneath, no doubt—although the detail is not shown on the drawing—mounted on the buckle of an inverted spring each side; it is clearly evident that no weight was carried on the pivot. The pivot itself, as customary also with Norris Philadelphia designs, was about 3½ ins. ahead of the midway distance between the axles. It is also noteworthy from the photographs that the makers "plate" is formed on the side of the steam-chest and not as in the Philadelphia-built Norris engines to Austria where it is composed of a large plate applied to the cylinder casing, as very clearly exhibited in Fig. 31 further on."

The first production by Norris at Wien was a set of three 4-2-0 engines built in 1846 for the Austrian Northern (State) Rly.—always cited in Austrian accounts as having Makers' numbers 1 to 3—the first being named "Ransko" whilst Fig. 20 shows another of the same batch, Cyls. 15x21, Drs. 5/0, Boiler press. 85 lbs. It is at once apparent that

apart from being of the Norris *type* and of approximately similar axle distribution and boiler location, they entirely lack Norris Philadelphia features; mention of this has just previously been made and it will suffice to make comparisons of Figs. 20 and 21, with Fig. 16 and with (R. I. 20) to observe their dissimilarity with the former (Norris-Philadelphia) and close agreement with the latter (Gunther-Wien) design—all three classes built 1844-6.

The next engines were also a set of three, of 4-2-0 type and generally regarded as having been makers' numbers 4 to 6, built for the K. F. N. in 1846-7, one of these being shown in Fig. 21, Cyls. 15x21, Drs. 5/0, Boiler press. 95 lbs. They were very similar to the previous set—like them being without Philadelphia features—and where differences exist between the two sets, as for instance the form of dome casing, they are explainable as conforming to the preferences of the particular railway. As to their constructional features it may be said that the relative disposition of boiler, cylinders and wheel base was Norris, but the Bogie was "tucked under" a fair amount whilst the slide-bars were of four-bar normal pattern. At the time the photographs were taken both sets of engines had link-motion valve-gear, and link-motion is shown on the drawing, in which respect, as in the four-bar pattern slide-bars, the design was well advanced.

It is in the nature of an anti-climax to so abruptly terminate this account of the productions of the Norris Brothers in Austria, after the glowing forecasts and post-mortem accounts recorded in the earlier part of this account; but everything goes to prove that the foregoing six locomotives comprised the whole output of complete locomotives at their Vienna Works. There is no doubt, however, in the author's opinion, that all the 24 Norris-built 4-4-0 engines were constructed in Philadelphia, which obviously predicates the acceptance that the Norris Works in Wien only constructed a total of 6 locos.; it is quite possible that although built principally in Philadelphia, in some cases the former may have had many of their details provided, and/or were finished off, by the Works in Wien. Harrison, in extracts previously referred to (25), characterized the Norris locomotive building venture in Austria as "no very great success" and this from a contemporary locomotive designer seems to sum up the situation.

4-2-0 TYPE NORRIS PATTERN LOCOMOTIVES PRODUCED BY CENTRAL EUROPEAN BUILDERS

A brief description of the earliest railways and initiation of locomotive building in Austria is necessary as an introduction to dealing with the Norris type locomotives produced in Central Europe.

The earliest line was that which became known as the Kaiser Ferdinands Nordbahn (K. F. N.) and a number of trials and special trips were carried out between Floridsdorf and Wagram of this line from November 1837 (the first locomotive being a Stephenson 2-2-0 type named "Austria") whilst the first service actually starting from Vienna (Wien) was from Wien over the Danube to Floridsdorf and Wagram

in January 1838, the line being opened to passenger traffic as far as Brunn in July 1839. Another line, the Wien-Raab Rly. was first opened in May 1841 from Wien to Wiener-Neustadt and on to Gloggnitz in 1842; Gloggnitz was not on the originally intended main line to Raab which latter portion was not opened until 1846. Before this however the name had been changed to Wien-Gloggnitz Rly.; the Gloggnitz branch later formed part of the through route via the Semmering pass—where the famous locomotive competition was held in 1851—as a portion of the Southern State Rly., the earliest section of which had been opened in 1844.

The Northern State Rly., begun in 1839, opened its first section in 1845. Meanwhile the Lombardo-Venetian Rly. a system of lines from Milan to Venice had been projected and commenced in 1840 and a part—then of course entirely unconnected with Wien—between Milan and Monza was opened in August 1840 and further parts of the route eventually extending from Milan to Venice were opened during the years 1842-6. At the time these sections of the line were opened, the territory formed part of the Austrian Empire but it will be considered as part of the Italian section of this account. Another railway which has to be considered is the Hungarian Central (State) Rly., at that time also being within the Austrian Empire, the first portion of the line being opened in 1846 and this is naturally included.

Dealing now with the railway and locomotive Works. In 1840 the K. F. N. Workshops, managed by an Englishman named Baillie—believed to have been the inventor of spiral (helical) springs in 1846—commenced an engine of the 2-2-2 type and of English pattern; this engine, named "Patria," was completed early in 1841, and was the first locomotive built in Austria. In 1840 also, the Wien-Raab Rly. commenced a Works in Wien under the charge of John Haswell (born 1812, died 1897) a Scotsman who had come to Austria in 1838 from Wm. Fairbairn and Son, of Manchester; these Works—opened in April 1840 and which later became the principal workshops of the Austrian State Rlys.—were really a separate Government concern and attained considerable fame from the locomotives produced there under the direction of Haswell. The first locomotive turned out early in 1841 was of the Norris 4-2-0 pattern for the Wien-Raab Rly. It may be mentioned here that the earliest engines supplied to the Wien-Raab Rly. included a number built in England of British pattern, and Haswell built a few also, but the vast majority of the locomotives turned out under Haswell were definitely derivatives from the Norris tradition. At the time when Haswell turned out his first engine which may fairly be considered as marking the "adoption" of the type in Austria, there were some 30 English pattern engines in Austria—16 on the K. F. N., 11 on the Gloggnitz and 5 on the Lombardo-Venetian lines.

In addition to the two railway-owned locomotive Works, W. Gunther commenced locomotive building at Wiener-Neustadt, a suburb of Wien, in 1842 and continued to 1860 when the concern was taken over by G. Sigl. Besides this one Austrian private firm, there was the locomotive building Works started by the two Norris Brothers in 1844-5; this was

in the Wahringer Strasse in Wien at a site to the rear of what later became Sigl's Works and which was also taken over by Sigl in 1851; and the work carried out there has already been dealt with. As will be seen further on, a number of other Central European locomotive-building firms which were springing up at the time participated in the development of the Norris type, expanding it finally to an extent where it is difficult to dogmatise upon a design as originating from the Norris or other lines of development. These firms can conveniently be mentioned here; Messrs. J. Cockerill & Co. of Seraing, Belgium, first locomotives for Austria 1838 but first Norris type for Austria 1844; J. J. Meyer of Mulhouses, first locomotive to Austria 1841 and first Norris type to Austria 1844-5; E. Kessler of Karlsruhe—later combined with the Esslingen Loco. Co.—first Norris type locomotive—for Wurtemberg—in 1846; J. A. Maffei of Munich, first locomotive for Austria—a Norris type—in 1847 and C. Henschel of Cassel, first locomotive built—a Norris type—in 1848.

The first engines of Norris type built in Europe were likewise the first locomotives built under Haswell at the Gloggnitz Rly. Works, being a series of six built for that line, see Fig. 22 which illustrates "Wien" the first engine completed early in 1841 Cyls. 10⅝x18, Drs. 4/1¾. As will be seen they were very close copies of Norris Class "B," even to the bogie pivot ahead of the centre, the connection of the motion plate with the boiler, the "two-bar diamond-fashion" slide-bars, and the drop-hook valve-gear. Four further, but larger engines, Cyls. 12½x20½, Drs. 4/8 and thus corresponding to Norris Class "A" were built in 1842-3 and it is probable they followed the design of "Wien."

The first changes in design were the provision of a more effective bogie frame, of plate-frame construction, a change from the favourite slide-bar arrangement of Norris to one composed of a slide (combined with the pump connection) on the inner side of the crosshead, the arrangement—the only available photograph does not show the details very clearly—being placed far back and a very short connecting-rod resulting; also the commencement in a slight degree, of the moving back of the bogie. These features appear in the first engines built by the then new firm of Gunther in 1842-3, Cyls. 12½x18¼, Drs. 5/0, Boiler press. 75 lbs. which represents one of the six engines built in those years for the Austrian Northern (State) Rly. In Fig. 23 is reproduced a photograph of an engine of the same class in which some differences from the drawing will be observed; the principal one being the riding-valve or double valve-chest system of Egells with variable cut-off obtained by advancing the eccentric, the hand-wheel for operating the change appearing on the boiler side above the driving wheels. Other than the above-mentioned changes these locomotives were, next to Haswells of 1841-2, closer copies of Philadelphia practice than any which succeeded. These engines were followed by 11 others by Gunther in 1845 for the same railway, identical in design but somewhat larger and without the "cut-off" valve, having Cyls. 14x21, Drs. 4/8 (R. I. 18). Meanwhile Haswell, in a series of 12 engines for the Southern (State) line during the years 1844-6, Cyls. 15½x22¾, Drs. 4/1¾ used his peculiar form of firebox

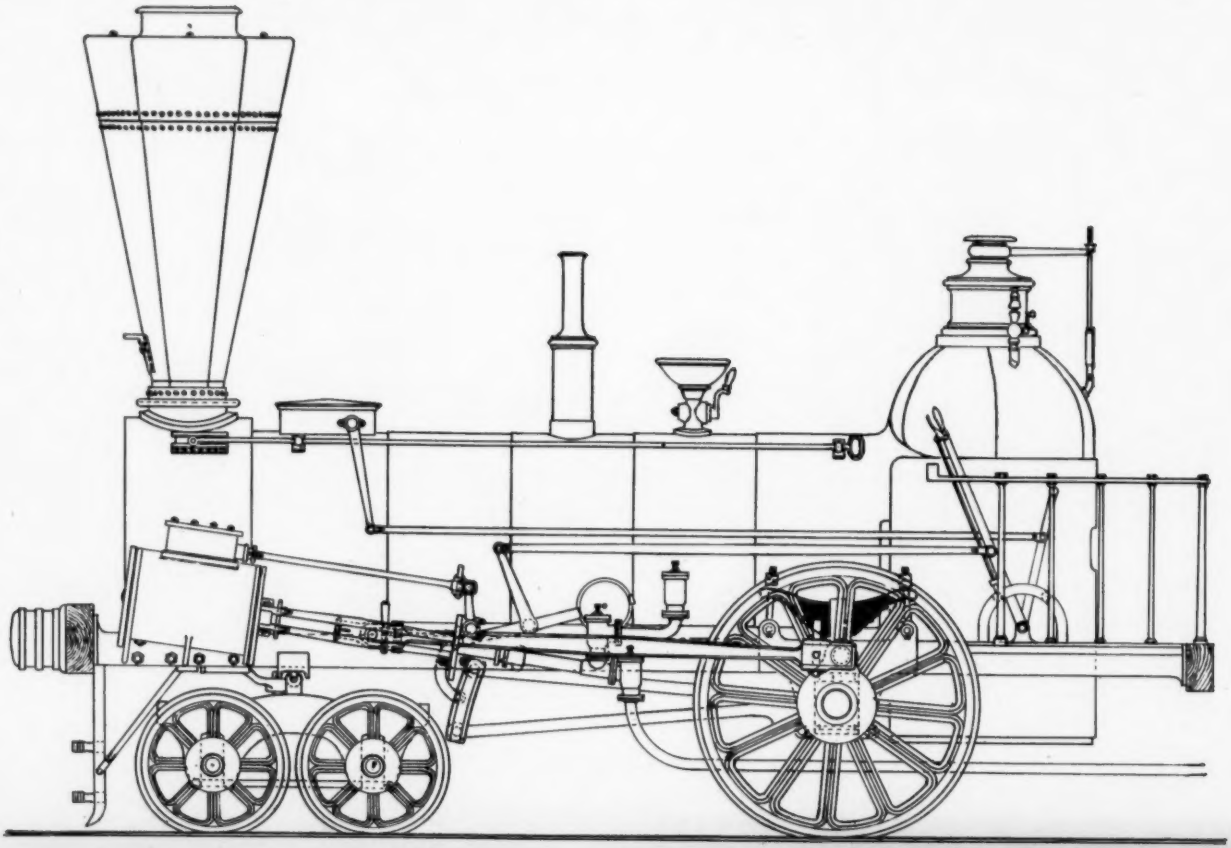


Figure 19

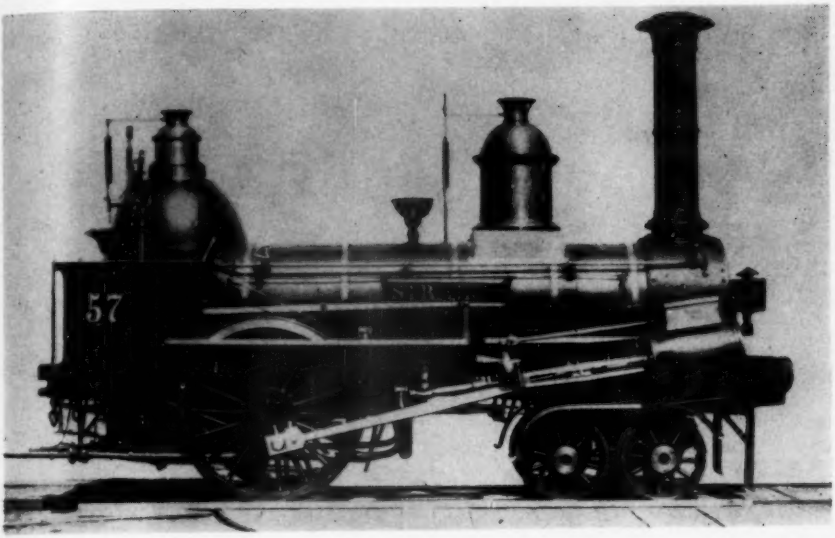


Figure 20

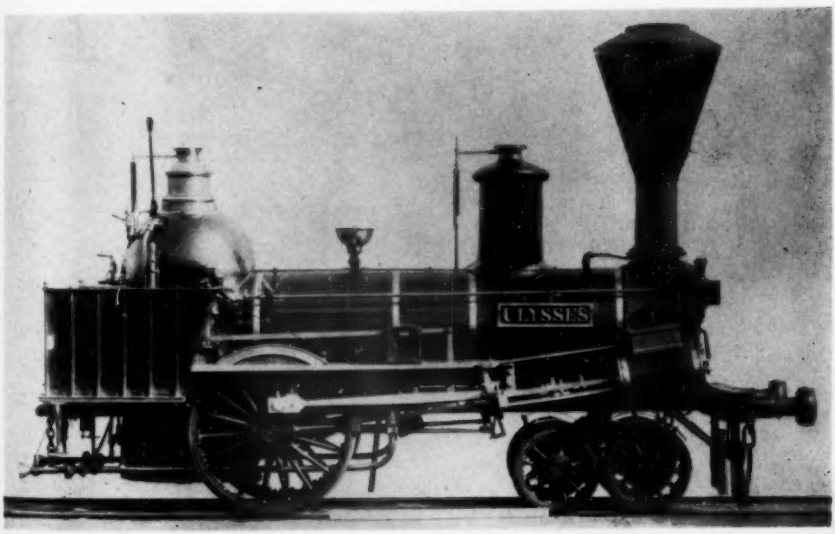


Figure 21

Figure 19

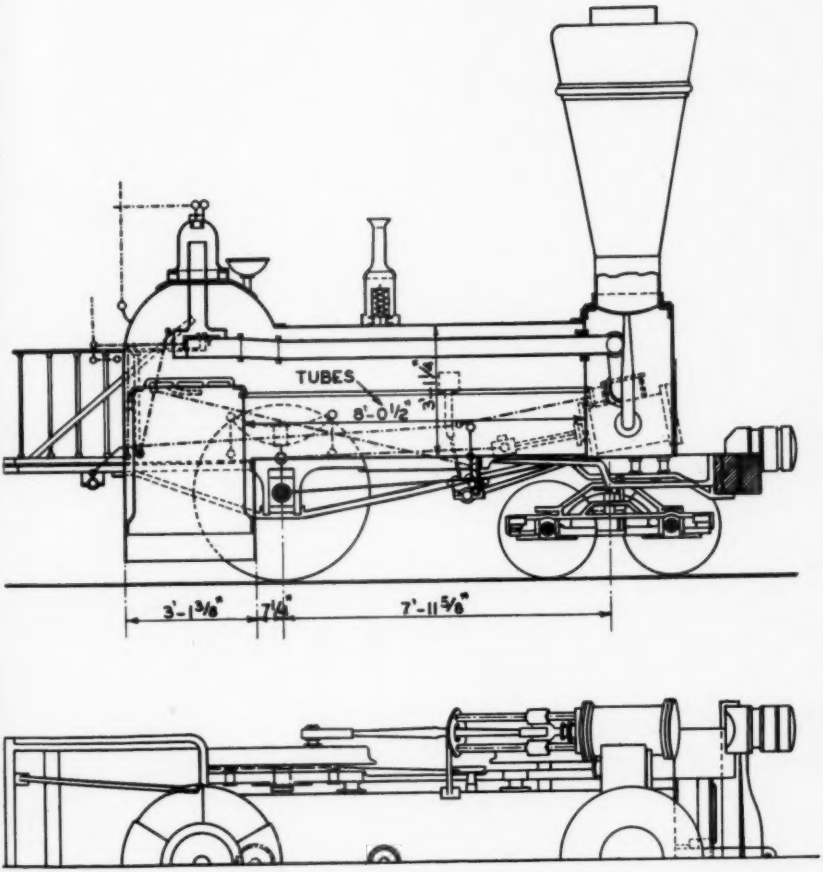


Figure 22

Figure 23

Figure 24

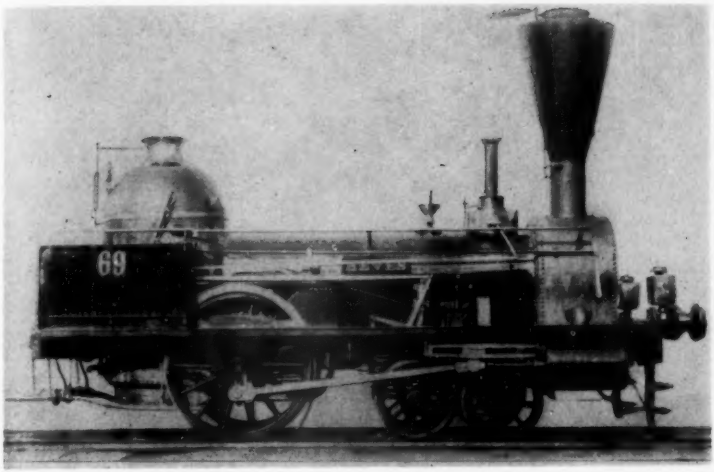


Figure 25

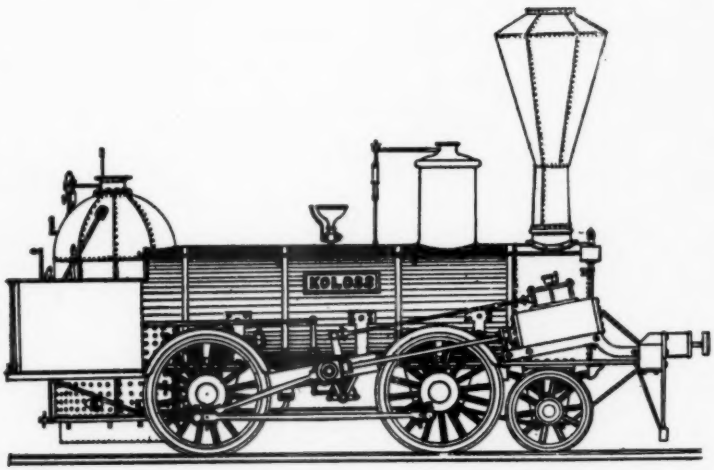


Figure 26

just previously applied to his 4-4-0 type, (to be referred to later) and adopted plate frames, not only to the bogie—which had the pivot central—but also for the main frames; and one of the earliest of this set of engines is believed to have had the first link-motion valve-gear in Austria; curiously enough the Norris horizontal two-bar diagonal form of slide bars was retained on the 4-2-0's. The reason assigned for Haswell's change from the Bury-derived firebox is that a number of continental-built examples had already exploded by 1844.

The next changes in design, one drastic and the other less so—took place more or less contemporaneously during 1844-6—the former being the moving back of the bogie in combination with dropping the cylinders to a horizontal position, and the latter merely moving the bogie somewhat further back than had previously been done whilst keeping the cylinders in the typical Norris position.

The former was done by Meyer in eight engines for the Austrian Northern (State) Rly. in 1844-5 see Fig. 24 Cyls. 16x24¾, Drs. 4/1¾, Boiler press. 90 lbs., and by Cockerill in 1845-6 in eight engines for the Hungarian Central Rly. as seen in Fig. 25 Cyls. 15x22, Drs. 4/11. These engines constituted the first considerable departure from the Norris lay-out, as besides the referred-to changes, the Meyer engines had a remarkable firebox and signs of the deepening of the bar frame in its metamorphosis into the plate frame; also some had a separate "riding" cut-off valve in the steam-chest apparently operated by the so-called Meyer valve-gear whilst others had link-motion. The Cockerill engines are noteworthy in having the valves inside the frames and apparently they were operated by link motion, whilst the regulator was placed in a low dome near the smokebox, an arrangement adopted by Henschel in 1848 as will be seen later. The slide-bars of both designs are interesting, particularly that of Cockerill's which was a species of four-bar fore-runner of the Laird pattern, whilst the inside valve-chests are believed to be the only case of their use with 4-2-0 engines.

The lesser change, moving the cylinders somewhat more rearwards, was done by Cockerill, 1845, in a series of 24 engines for the Northern (State) Rly. (R. I. 19) Cyls. 15x20, Drs. 4/1½, and in 4 by the same firm in 1845-6 for the Hungarian Central Rly. which include the first locomotive to run in Hungary; also in 1846 by Gunther in six engines for K. F. N. Cyls. 14½x22, Drs. 4/1¾, Boiler press. 90 lbs. The Cockerill engines, apart from the position of their cylinders, had details similar to Fig. 25 and so are not illustrated, whilst those by Gunther it will be seen had quite a modern slide-bar arrangement and their slide-valves were operated by link-motion. Besides those by Gunther for K. F. N. the same firm built four in 1846 for the Northern (State) Rly. (R. I. 20) in which the details, with the exception of the dome on the boiler-barrel, were so like the three engines built at Vienna by Norris the same year for the same railway as to make almost certain some connection between the two sets of engines. All the Cockerill and Gunther engines of the groups just mentioned should have had a very good weight distribution.

It has already been pointed out that the engines built by Norris at Wien were similar in general to these latter groups and had little in

common with Philadelphia practice. The question of whether the horizontal cylinders and excessive front overhang was an improvement on the steeply inclined cylinders is not susceptible of judgment upon subsequent practice because the year 1846 witnessed the discontinuance of building the 4-2-0 type and the commencement of the vogue of the 4-4-0 simultaneously.

In all there were 111, 4-2-0 Norris type constructed on the European Continent including the six by Norris at Wien; all of which (two by Kessler of Karlsruhe for Switzerland are mentioned in a later section) have been dealt with, excepting 5 for Austrian Southern (State) Rly. and 3 by Cockerill to the Berg-Mark Rly. which are not believed to present novelties beyond the descriptions given, whilst there remain two locomotives, one built in the shops of the Brunswick Rly. about 1841 for that railway, and one by Jacobi, Naniel, and Huysen, later part of the Gutehoffnungshutte of Sterckrade, Germany, for the Dusseldorf-Elberfeld Rly. in 1842, of which it is only known that the latter had the following dimensions Cyls. 12½x18, Drs. 4/6.

As we have seen, all the 4-2-0 designs except the later ones of Haswell retained some form of "domed" firebox, altered to a remarkable degree in the 1844 design of Meyer in which there is about as much volume in the "vertical cylinder" of the firebox as there is in the barrel; the joining of the firebox shell-plate to the barrel looks sufficiently striking above the centre-line and one would like to know "how it was done" in the case of the throat plate below. It is not known what was the pattern of slide-bars of Haswell's later 4-2-0 engines—his first 4-2-0 designs having had Philadelphia 4-2-0 horizontal pattern—but he may early have developed on the lines of "Millholland" vertical; which pattern will appear clearly in Haswell's 4-4-0 engines dealt with further on. Also the use of bar framing was supplanted at least as early as 1844 by Haswell, who may be considered the closest follower of Norris ideas; whilst in the case of the 4-4-0 type, as will be seen, no bar-framed example seems to have been built in Europe. It is not proposed to consider these 4-2-0 Austrian designs in greater detail, as the constructional features mostly pertain to the development of locomotive design in general, but mention should perhaps be made of the valve-gear; the Norris drop-hook of course soon went out of favour—even so early as the 1842-3 engines of Gunther there was an "expansion-valve" and Meyer is "credited" with an adaptation of Norris's gear afterwards generally referred to in Europe as Meyer's valve-gear—whilst by 1844-6 the link motion had become normal practice. The 4-2-0's evidently became quickly outclassed by the 4-4-0 type and this is not to be wondered at in view of the gradients and curves of the Austrian lines, excepting a portion of the K. F. N. and of the Lombardo-Venetian Rly.

That this was so even in the case of the lesser graded lines is supported by the appearance of two 2-4-0 type engines by Gunther in 1844 for the K. F. N.; these were remarkable hybrids as will be seen from Fig. 26, Cyls. 15x22, Drs. 4/1¾, boiler press. 90 lbs. Although the grouping of the two forward axles would suggest some form of bogie, the coupled wheelbase was rigid and it seems certain that the small lead-

ing axle had little flexibility; the crosshead and slides were clearly similar to those of Gunther of 1842-3 and of 1845 to the Northern (State) Rly. and in the 2-4-0 case the position of the slides and the long piston-rod were necessary on account of clearance for the crank pin of the front coupled wheel. These engines cannot be said to have influenced later design and are a somewhat striking example of pushing a modification of a good design to unreasonable lengths.

Of an entirely different order of ideas was the development of the Norris by A. Borsig of Berlin; this firm's first locomotive, of July 1841 for the Berlin-Anhalt Rly., being of the 4-2-2 type is shown in Fig. 27. It was clearly on the same lines as Rogers earliest engines as "Stockbridge" of 1842 etc. and of Baldwin's No. 146 of 1841 except that the latter had outside frames; the object no doubt being to improve the riding by the additional wheels and equally without doubt fore-doomed to be "slippery." The Borsig was evidently a close copy of the Norris 4-2-0, having the bar frame, the Norris slide-bars and pump arrangements and a true "Bury" firebox; the drawing is "sketchy" as regards the valve-gear and the bogie but the former was evidently too early to provide for expansion and the latter appears to have had its pivot somewhat in advance of the centre. The cylinders are variously stated to have been 11 or 11½x18 and the pressure 80 lbs.; the driving wheels being 4 ft. 6 in., whilst the bogie and trailing wheels were 2 ft. 6 in. diameter and as the total wheelbase was approximately 13 ft. 9½ in. steady running would have been attained.

However the lack of adhesion inevitably told against the type—in Germany as in U. S. A.—and after building a limited number, 3 engines each for the Oberschlesien and the Berlin-Stettin Rlys. respectively—and possibly a few more—during 1841-3, the firm turned to the 2-2-2 type. These 4-2-2 designs are interesting engines, being remote forerunners of Stirling's "eight-footers" of the Great Northern Rly. of England in the same way that certain early U. S., 4-2-2's with inside cylinders and outside frames foreshadowed Johnson's Midland Rly. of England inside cylinder 4-2-2's; the type being unsurpassed for steadiness at high-speeds.

4-4-0 LOCOMOTIVES EXPORTED BY NORRIS TO CENTRAL EUROPE

As in the case of the 4-2-0 type the Norris-built engines from U. S. A. are first dealt with as they seem to have fulfilled the role of pioneers, notwithstanding that two 4-4-0 Norris type engines were built by Haswell at Wien in 1844 and at least two 4-4-0 engines had been built by Cockerill in the same year; in both cases being forerunners of a long series of similar engines. The European-built locomotives are described in the succeeding section.

The introduction was a set of three engines built by Norris in Philadelphia in 1845 for the Wurtemberg State Rly. which were of firebox-between-axles pattern, similar, but with developments, to the "Orange" (see Fig. 11) and they are illustrated here by Fig. 28 Cyls. 12½x25,

Drs. 5/0. The differences consisted in the boiler-supports and the motion-plate which followed the 4-4-0 "1843" pattern, as also the "B" form of firebox, but changed slightly; the cylinders were somewhat more forward in relation to the bogie than any previous Norris 4-2-0 or 4-4-0, whilst the engines were equipped with equalising-beams between the coupled axles having an inverted spring under the main framing, instead of the separate overhung springs which appear in the drawing of the "Orange." They also had the link-motion—and would appear to be amongst the earliest American-built locomotives so fitted—instead of the simple drop-hook gear of the "Orange"; but they had the Norris "two-bar-diamond-fashion" slide-bars and whilst the bogie-frame was of more substantial construction the pivot remained in advance of the centre as in early Norris designs. The order for these engines was obtained under very competitive conditions and as the circumstance possesses interest—beyond the merely Norris aspect—some account is here given.

As the preliminary to the provision of locomotives for the Wurtemberg Rly. offers were obtained from various English and European builders, as also from Baldwin and W. Norris in U. S. A., and a very interesting tabulated account of these offers appears in Meyer 1924 (45). Apart from the call for tenders however, it appears that the Civil Engineer of the railway, E. Klein, had been visiting America, as a result of which his recommendation was to "obtain the locomotives of the best design in the country of origin" (America) and to use them afterwards as samples for the intended locomotive-building works at Esslingen. The Wurtemberg Rly. commissioners therefore ordered three 2-4-0 type locomotives from Baldwin of Philadelphia (these locomotives are of interest in themselves in that they had Baldwins patent flexible truck embracing the leading axle and the front coupled axle) and three 4-4-0 Norris-type locomotives from that firm's Works in Philadelphia. At the same time the commission decided the gauge of the railway be established at 4′-8½″ notwithstanding that the neighbouring state of Baden had a gauge of 5′-3″. However the commission considered modifications desirable to the American system in order to obtain economy in fuel by the employment of some form of variable expansion, it being considered that Kessler's offers left less doubt about guarantees in this regard; and it was afterwards decided that the supposed advantages of "purchase from the country of origin" were not substantiated, especially the imported locomotives were criticised because of the large amount of cast iron instead of wrought iron employed. Nevertheless as will be seen, Kessler's first engines to the Wurtemberg line derived much of their design from "the country of origin." The Norris engines gave better results than the competitive 2-4-0 Baldwin engines—which latter were the second, third and fourth locomotives delivered to Europe by Baldwin's—and thus the Norris type was adopted by the Wurtemberg Rly.; as also by its associated builders Kessler-Esslingen, as will be shown in the following section.

The next Norris-type engines were two, of 1845-6, for the Bergisch-Markische Rly. Germany upon which line they appear to have been the first locomotives. Few details are available and it is not known whether

they were of firebox-between-axles pattern similar to the above-mentioned to Wurtemberg or of the Norris "long-boiler" pattern dealt with below; their cylinders were 15x20 and their driving wheels are believed to have been 4/. About the same time, 1846, two locomotives were also supplied to the Hannover (State) Rly., of which even less information is available, their cylinders being 15 in. diameter.

Before describing the next engines of the 4-4-0 type from Philadelphia it is necessary to deal with a series of authentic and apparently contemporary drawings of Norris locomotives which at one time formed part of the collection of early railway material gathered by Major Pangborne and exhibited at the Chicago Exposition of 1893; this afterwards continued in the possession of the Baltimore and Ohio R. R. and after many vicissitudes part of it was rediscovered—partly at the writer's instigation—in recent years by Mr. Thomas Norrell. By courtesy of Dr. Carl Mitman of the U. S. National Museum the writer has been facilitated with copies of these "Norris" drawings. As far as the writer is aware there are six of these drawings, one representing a 4-2-0 and the other five 4-4-0 Norris engines; the former has already been dealt with above.

Of the others, one—designated "Prussia"—Royal Locomotive Works—Austria—Norris Bros. of Philadelphia U. S. A. Managers—1846" represents practically a standard 15x22, 5/0 Norris engine of the period similar to those used in U. S. A., having a firebox between the D. and T. wheels, a normal type of main framing and axleboxes, being in fact very like the "Orange" of Erie R. R. (see Fig. 11) but with equalizing beam and underhung springs between D. and T. axles. The slide-bars are of two-bar style arranged as a horizontal pair and placed "square-fashion," the boiler, firebox and mountings being typical Philadelphia pattern. The drawing shows the Link-motion, in which respect these engines of Norris were well ahead in U. S. A. current practice of the time. By the disposition of various details which correspond with a drawing of 4-4-0 Norris engines on an Italian railway—refer to Fig. 37—it seems that engines to this design were supplied to Italy in 1846 (Nos. 351 & 358) and probably Nos. 359-60 to the Hessian Northern Rly. in 1848—although the railway records in each case show 14x22 cylinders—possibly also the two engines (Norris Nos. not known) to the Hannover State Rly. in 1846.

Three other drawings, generally similar to one another, are also of 4-4-0 type, but of "Long-boiler" pattern (i.e. all wheels in front of the firebox). All three are designated in similar form to that given in the previous paragraph, one (called here "A") has the prefix "France" and the suffix "1845," "B" has no prefix but has date "1847," whilst "C" has "Belgium 672" and "1848." The boilers shown in all three drawings are identical and would correspond to the boilers of Norris Nos. 310-19 and 331-42 to the Southern Rly. of Austria, with the important exception that the Norris-Wien "decorated" pattern of firebox dome casing and disposition of boiler mountings is shown instead of the regular Norris-Philadelphia pattern which the actual engines referred to had (vide Fig. 31). Further the unusual pattern of wheels shown on

all three drawings, having "staggered" spokes set close together around an unusually large wheel-boss, are not present in the engines referred to.

Apart from the features mentioned—a good link-motion is shown on all three drawings—the principal variations are:—

"A" The Norris "Patent" articulated frame comprising all four D. and T. axleboxes, two-bar "old" Norris pattern slide-bars, and—most unusual—the valve-chests placed between the cylinders and the sides of the smokebox.

"B" "Patent" articulated adhesion frame as in "A," but valve-chests on top of cylinders as usual, and—a new feature which is typically Norris-Wien—four-bar style slide-bars.

"C" Normal non-articulated main framing with integral pedestals for the D. and T. axleboxes and, in this case, having an equalizing-beam between; also normal valve-chests and the Norris-Wien four-bar slide-bars. These relatively small differences hardly warrant separate reproductions and hence drawing "C" is given in Fig. 29 to represent the series.

The fifth 4-4-0 design is distinctive in form from the other drawings and therefore described separately, and last, although evidently of earlier date than the others, it being also of undoubted authenticity; it is a lithograph with a title dedicating it to an Austrian dignitary. Although the lithograph has no date the design can easily be dated 1843-4, in fact it is a long-boiler edition of the "Patent 4-4-0 Philadelphia" of 1843, and its particular interest lies in it exhibiting so plainly the remarkable flexible sub-frame to the coupled axles already mentioned in the first section when describing the latter engine; in the drawing of "Semring" however the pair of long articulating rods (one on each side) reaching from the forward end of the sub-frame to a pin-point just above the bogie, has a cottered-end attachment at the rear evidently in order that wear could be taken up at that point. The more this flexible sub-frame is considered the more troublesome in use it seems likely to be, and this particular drawing shows what appears to have been provision for flexibility between the two coupled axles, as the horizontal frame on each side, which also serves as the member transmitting the weight over the two axles, works into circular horizontal sockets apparently containing adjustable cushioning springs. An intriguing newcomer is the safety-valve shown on the boiler barrel as although its leverage, spring-balance etc. follows the orthodox (or unorthodox) Norris custom, the pillar itself is clearly an interloper—it says plainly "I don't really belong here"—and no doubt its presence was unwelcome to the Norris draughtsman. The coupling-rods were composed of a pair of round bars with many bolts and nuts. Although the drawing carried the name "Semring" it has nothing to do with the famous "Semmering Incline" trials, which took place in 1851, but as the Gloggnitz line was projected to eventually pass that difficult region, the reason for the name is evident. Statements have appeared suggesting that such an engine—and named "Semmering"—was actually supplied by Norris to Austria, but no trace of such can be found unless it appears under an-

other name as one of the 22 very similar engines supplied by Norris in 1846 from Philadelphia to the Southern (State) line, and referred to below.

None of the collective or individual constructional features of these three drawings nor of the lithograph can be paralleled in the Norris engines so far known on the railways of Austria or Germany, whilst regarding the designations upon the drawings as for France and for Belgium, it has not been found possible to trace any such engines on the early railways of those two countries beyond those of 4-2-0 type from Philadelphia referred to in a previous section. Hence the judgment seems inescapable that the three drawings were essays—perhaps alternative proposals or "stock" designs prepared to meet possible enquiries for supply; it seems further probable that any actual orders possibly resulting from these designs—quite obviously Norris-Wien designs—were carried out somewhat differently in details by the home firm in Philadelphia, as suggested previously in this account—see Fig. 31. The lithograph, from its probably early date, may even have been a forerunner of the establishment of the Norris Works in Vienna, sent to Austria from the U. S. A.

Engines of "long-boiler" pattern somewhat similar to "Norris-Wien" drawing CN (Fig. 29 above) were supplied from Philadelphia, also in 1846, being 4 for the Baden State Rly. and Fig. 30 illustrates these engines, Cyls. 14½x20, Drs. 4/7½; generally similar to a number of long-boiler 4-4-0's to the Southern (State) Rly. next to be described, they were practically a passenger engine version of these latter. The extant drawing shows them with link motion and with bar framing of normal but somewhat advanced type; the springing of the coupled wheels however is very unusual, there being a single spring each side for the main driving axle and an underhung transverse spring for the coupled axle, the bogie is also shown with a central pivot. It is possible that the drawing may represent the engines after some changes had been made.

The foregoing engines were followed also in 1846, by two for the K. F. W. Hessian Northern Rly.; again it is not known whether they were firebox-between-axles or long-boiler pattern, but they had Cyls. 14x20 and Drs. 4/0. A year or two later, in 1847-8, two other engines were supplied by the firm to the same railway, these having Cyls. 14x22 and Drs. 4/9 or 5/0. Some of these engines were eventually converted to saddle-tanks and an illustration of one of the smaller pair so modified, taken in the 1860's, appears in (R. I. 17), as already mentioned.

The engines which followed the previous 13 Norris-built 4-4-0 were 22 from Norris U. S. A. for the Austrian Southern (State) line in 1846, the designing of which may quite likely have anticipated Haswell, vide the "Semring" drawing on which they were obviously based—and on which Haswell's may also have been based—and was in any case only a further progress from the "Gowan & Marx" of Eastwick & Harrison of 1839. The engines were of two groups, differing slightly in size, one of the 12 smaller being shown in Fig. 31 Cyls 14x20, Drs. 3/7½, whilst the larger had Cyls. 14½x20 and Drs. 3/7½—they had 90 lbs. boiler-pressure; as mentioned elsewhere they were no doubt built in Philadel-

phia notwithstanding Austrian accounts sometimes attributing them to the Norris works at Wien. They have the true Norris touch and follow the "Semring" design although they seem to have had normal framing and the equalising between the coupled axles was by means of an inverted spring above the main frame; otherwise the remarks to "Semring" apply except in regard to the pattern of safety-valve column and its position on the barrel.

Before leaving the Norris-built 4-4-0's mention must be made of two engines, originally very similar to the preceding 22 and supplied by Norris from Philadelphia in 1846 to the Hungarian State Rly., but converted about 1855 to 2-4-0 type without other change than the substitution of a single leading axle for the bogie. Illustrations of these engines, they had Clys. 15x20, Drs. 4/0 (R. I. 21) appear in various Austrian engineering publications; they have sometimes been attributed to the Norris Wien works, but although their original design—as 4-4-0's may well have been based on the Norris-Wien designs—vide Fig. 29—all their constructural details including the typical slide-bars set "diamond-fashion," are of Norris Philadelphia style and sufficient to prove Philadelphia origin. Their conversion was a similar case to the one engine of the 8 by Cockerills of 1844-5 to K. F. N. converted from 4-4-0 to 2-4-0 (R. I. 22).

It will thus be seen that in all there were 39 Philadelphia-built Norris 4-4-0 to Central Europe—15 to Germany and 24 to Austria—the majority being of "long-boiler" pattern.

4-4-0 NORRIS-TYPE LOCOMOTIVES BUILT IN EUROPE FOR AUSTRIA, GERMANY AND WURTEMBERG

The first 4-4-0 Norris type in Europe was produced by Haswell of the Gloggnitz Railway works before-mentioned, who delivered two in 1844—and afterwards from 1846 many others to various lines—to the Gloggnitz Rly.; Cyls. 15½x22¾, Drs. 4/8 ("Adlitzgraben") and it will be seen they correspond to a bogie "long-boiler" design very similar to Norris' "Semring" drawing from which they may derive. As to cylinders etc. the design follows the Norris just described, but the slide-valves were inside the frames—as were all the European-built 4-4-0 Norris type except those by Henschel dscribed further on—and the slide-bars, although of the two horizontally-placed bar pattern previously mentioned, appear to have been round; it will also be noted that the firebox is not of the "Bury" pattern, being a hybrid apparently introduced—and certainly long used—by Haswell, having the rear part semi-circular but the top only comprising a half hemisphere and at a height suitable for connecting the shell-plate to the barrel in a straight-forward manner, and there was a dome on the middle of the boiler-barrel. These engines had plate-frames—of the built-up pattern with axle-guards (horn-plates) separate, similar to British practice of the time—and the bogie frame was also of plate; the bogie had the pivot in the centre, the coupled axles were equalized by a spring-cradle and single spring above the axle-boxes—and this is believed to be the first use of equalizing levers on a locomotive

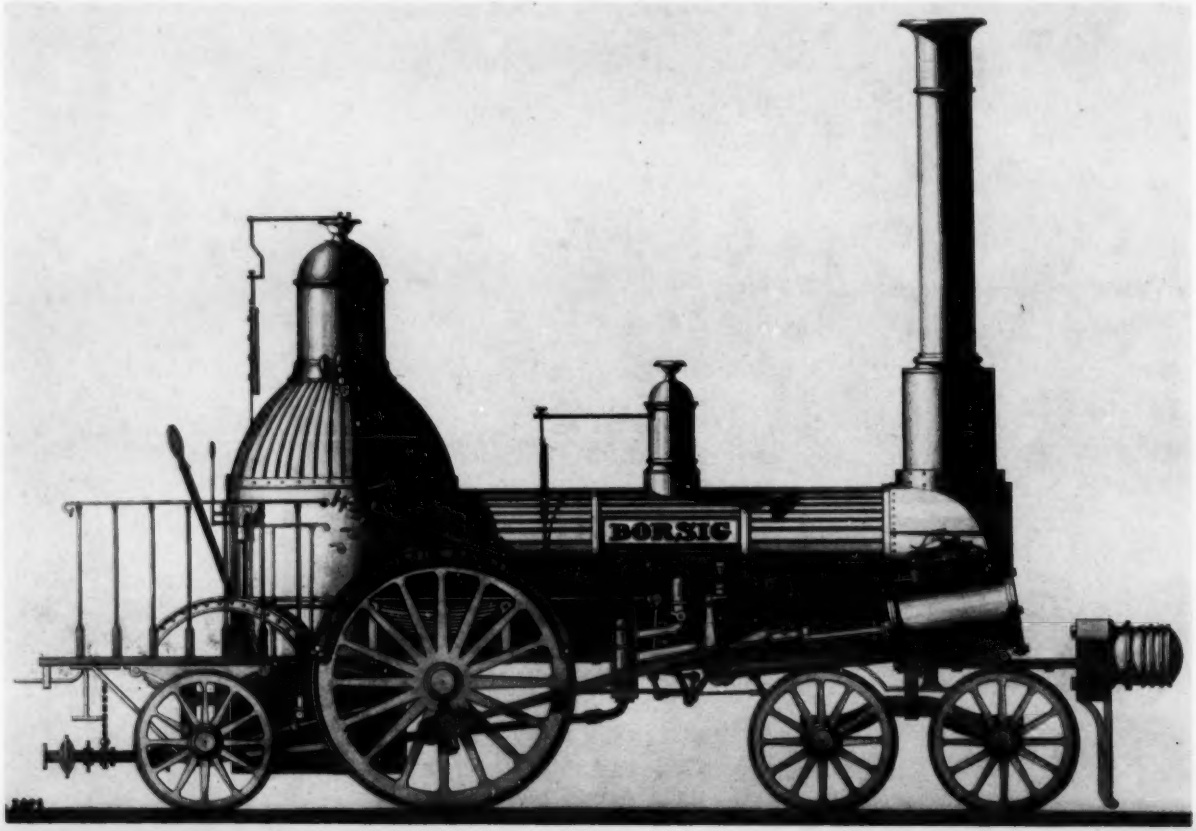


Figure 27

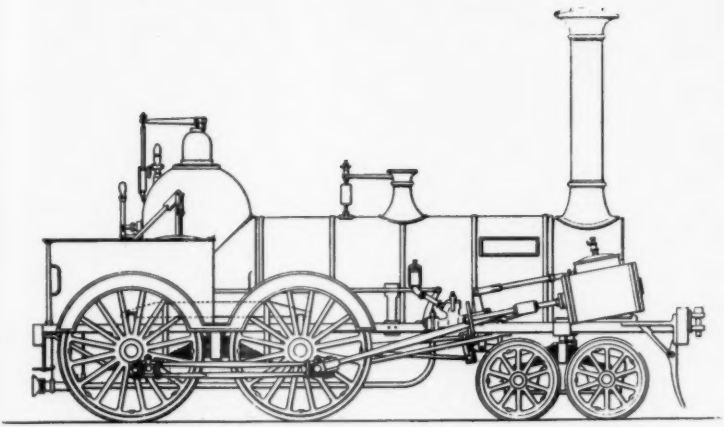


Figure 28

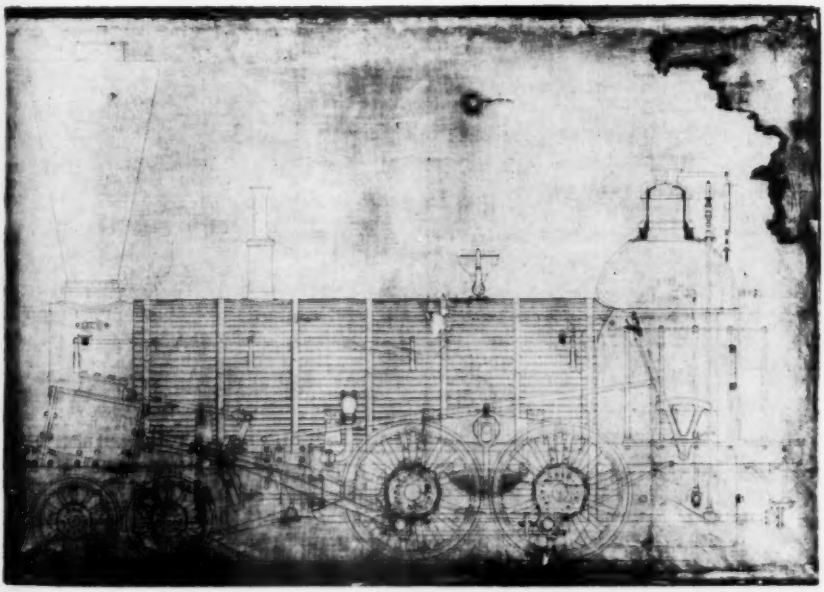


Figure 29

Figure 27

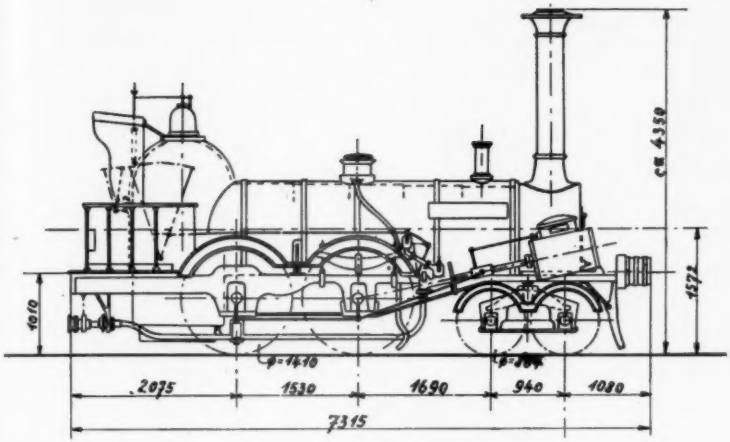


Figure 30

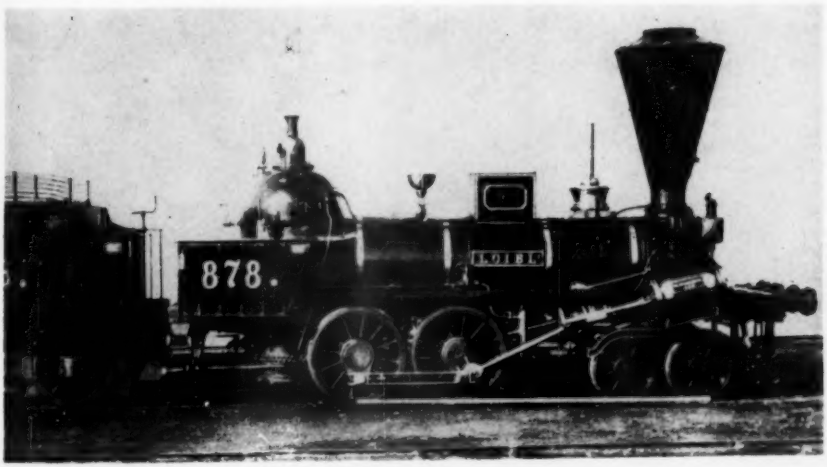


Figure 31

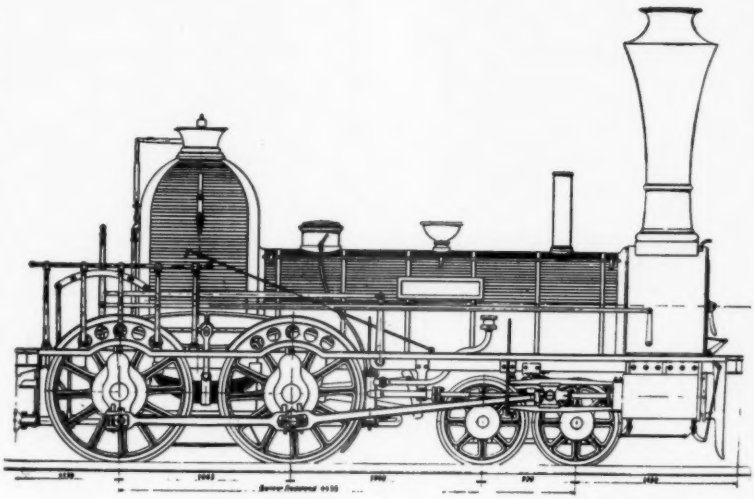


Figure 32

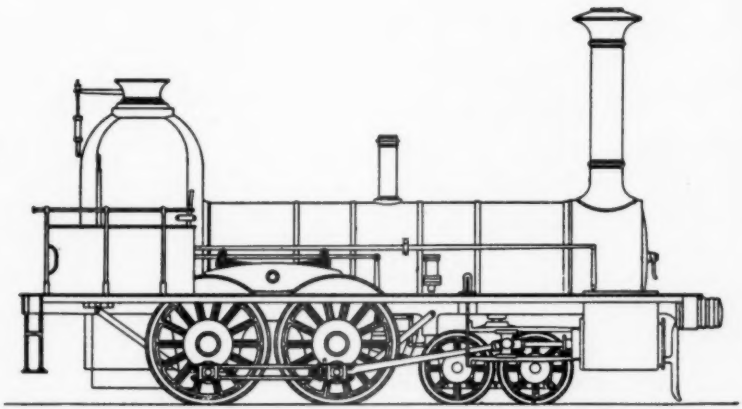


Figure 33

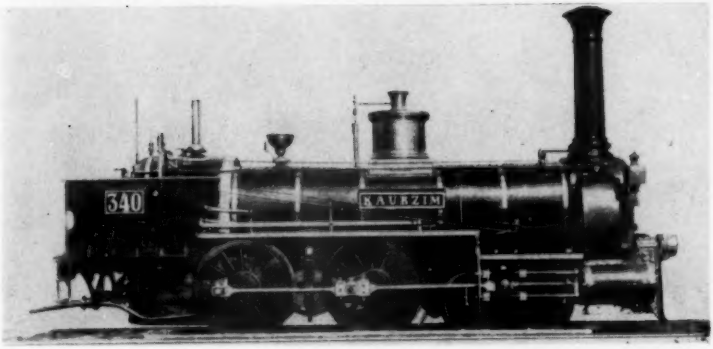


Figure 34

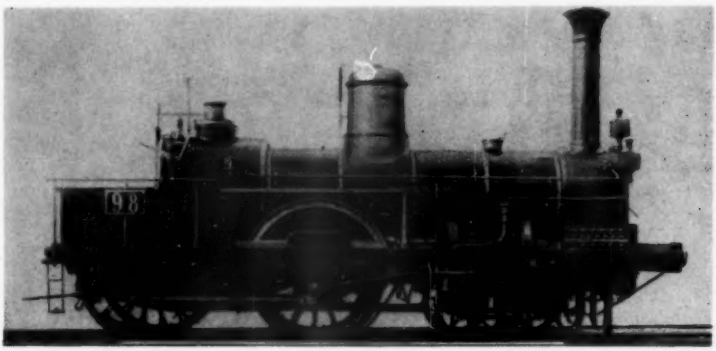


Figure 35

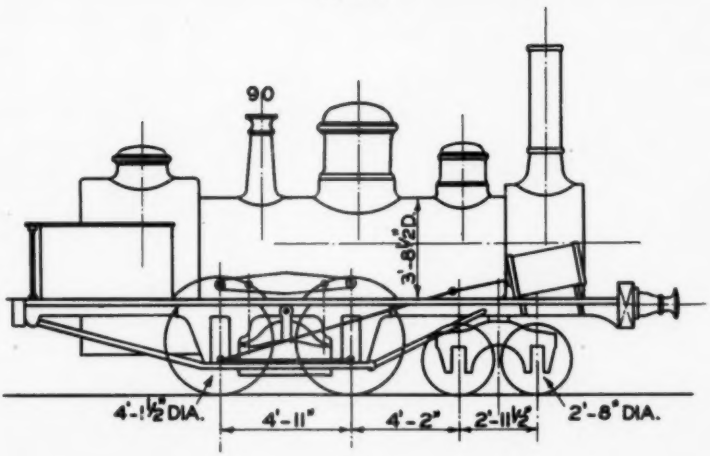


Figure 36

constructed in Europe. These engines were in fact very up-to-date for the time they were built and there need be no surprise that the design and its successors prospered. It should be added that the design of slide-bars was soon changed to the vertical pattern with the "stuffing-box packing" adjustment referred to elsewhere, also feed-pumps placed alongside the cylinders were soon added to the design and one of these later engines or the Austrian Southern (State) Rly. in 1845 appears in (R. I. 23) Cyls. 15¾x22¾, Drs. 4/1¾; some of the same design or other lines had 24 in. stroke. It is interesting to note that this "archaic" arrangement of slide-bars continued to be used by Haswell as late as 1852-3, that Gunther also used it fairly frequently up to 1850, and even occasionally Maffei.

At this time there were some 4-4-0 engines, believed to be very similar to the foregoing, of which 8 were built by J. Cockerill of Seraing, Belgium for the K. F. N. Austria in 1844-5, and some 11 during 1846-9 for the same line, but particulars, beyond that they mostly had 16x22 Cyls. and 4/2 Drs., have unfortunately not been obtainable. From a photograph of one of them (R. I. 22) which particular engine, as mentioned, was converted to 2-4-0 type in 1852, it is evident that at least the 8 of 1844-5 had the drive on to the rear coupled wheels.

The next in order was a set of 6 engines in 1846-7 (R. I. 24) by J. A. Maffei of Munich for the Austrian Northern (State) Rly. in which the practice of displacing the bogie rearwards and lowering the cylinders to a horizontal position—as had previously been done by Meyer and Cockerill on the 4-2-0 type—first appears on the 4-4-0; their cylinders were 15x24, Drs. 4/2 and they were of the "long-boiler" type, their fireboxes being of the Haswell pattern with a very large dome on the boiler-barrel and the slide bars were vertical pattern. They are not however illustrated here, as others built by different firms show development more conveniently.

In 1846 E. Kessler of Karlsruhe began to turn out 4-4-0 engines which were a combination of the horizontal cylinders of Maffei 1846 but with the trailing coupled axle behind the firebox, the first being a set of 6 for the Wurtemberg State Rlys.; these are shown in Fig. 32, Cyls. 14x22, Drs. 4/6. The features of these engines are sufficiently evident from the drawing, but it may be pointed out that the equalizer between the coupled axles was composed of a beam above and a single spring "right-way-up" below it—a somewhat rare arrangement; the boiler also is noteworthy in having a "Haystack" square-in-plan fire-box of the pattern favoured by Stephenson and other North-east England builders in the mid 1840's—and are amongst the earliest in which that firebox was probably copied. Kessler built 3 similar for the F. W. Hessian Northern Rly. and 6 for the Milan-Monza (Lombardo-Venetian) Rly. in 1848. Maffei, in 1847, had built 3 apparently very similar engines for the Wurtemberg State Rly. In 1847 Kessler's associated firm of Esslingen Works turned out 9 practically identical engines for the same railway, the first delivery, in October, 1847, named "Esling," being the first locomotive constructed by the firm; later, during 1849-52, 28 more were supplied.

In 1848 Gunther built 21 engines for the Austrian Northern (State) Rly. and these engines, illustrated in (R. I. 25), Cyls. 15½x24, Drs. 4/2, fell midway between the Norris and Haswell designs, having a modified Bury firebox, and with the cylinders fairly high up, but the bogie moved somewhat towards the rear; in these engines the motion, slide-bars and other mechanism had become established quite away from the Norris tradition, whilst a pump was placed alongside the cylinder driven from an extension of the crosshead gudgeon pin; this last arrangement having a very limited vogue in U. S. A. at the period.

In the same year 1848 Cockerill built 6 engines for the Austrian Northern (State) Rly. in which the principal difference consisted in the drive on to the rear coupled wheels—a compromise between the "Adlitzgraben" and the "Gowen & Marx"; Cyls. 16x22, Drs. 4/2, and their other principal points of interest are, a feed-pump laying alongside and *above* the cylinders, an equalizing beam above the coupled axleboxes and a firebox of the Meyer style (see Fig. 24).

It should be mentioned that Cockerill's had used the same drive on to the rear coupled wheels in at least 8, if not the whole 19, engines they built for the K. F. N. in 1844-5 and—as will be seen—on similar engines to Italy. There were also 12 other locomotives of the same type in Germany, 10 by Cockerill from 1847 onwards and 2 by Wever & Co. of Barmen in 1848-9; 5 of these were to the Berg-Mark Rly. and the others to the Prince Wilhelm Rly.

In 1848 the Esslingen Locomotive Works commenced to provide engines very similar to those previously-mentioned of Kessler & Esslingen, but of long-boiler type, the first being 2 for K. F. N. and 3 for the F. W. Hessian Northern Rly. Fig. 33 shows these engines, Cyls. 16x22, Drs. 4/2. The only noteworthy feature, other than the "Stephenson" firebox, is the perpetuation of the Norris "two-round-bar" coupling-rods.

The first engine built by Henschel & Son, Cassel, a 4-4-0 Norris type for the F. W. Hessian Northern Rly., was also completed in 1848; Cyls. 15x24, Drs. 5/0. This engine is quite close to the Norris design of 1845 to Wurtemberg—having the valves on top of the cylinders and having Norris's "two-round-bar" coupling-rods—and in fact can be considered a combination of a Norris with a Stephenson Haystack firebox pattern of boiler. It, however, had the coupled axles equalized in the same manner as Kessler's engine of 1846 (see Fig. 32 ante), and the regulator was placed in a low dome close to the chimney and being operated through a striking-rod lying across the boiler top in front of the firebox by a lever on the right side of the engine close to the reversing-lever.

It is impressive to notice the number of "first" locomotives of Central European builders which closely followed Norris—giving proof to the supposition mentioned previously that the Norris designs were welcomed there "because it was easy to copy them"; whilst the "first locomotives" of firms who did not start off with a Norris, were—very naturally—fairly close copies of English-built engines.

Many more of these different designs were supplied by the various firms referred to during the period up to 1854, and even beyond; in some

deliveries the particular builder's features continued, whilst in a somewhat lesser proportion the builders obviously incorporated features to the specific orders of the railway concerned and hence builders' individuality tended to decrease. The tendency to lower the cylinders to a horizontal position in front of the bogie became accentuated with time and a later example of Haswell's for the Austrian Southern (State) Rly. in 1850 is shown in Fig. 34. In the same year Kessler built two of this pattern for the Austrian Northern (State) Rly. (R. I. 26) in which the tall firebox almost as exaggerated as Meyer's of 1844-5, reappears. The total of all these European-built 4-4-0 outside cylinder engines, up to 1853, as far as the author's admittedly incomplete data show, was about 280—there being 176 in Austria alone—so that the derivations from the Norris type most certainly prove its influence in Central Europe.

When dealing with the 4-2-0 it was mentioned that the inclined versus horizontal-overhanging cylinders were not determined by subsequent practice; in the case of the 4-4-0 the same uncertainty is exhibited because there is clearly vacillation over many years between the two systems; this seems to indicate that both were somewhat unsatisfactory and looking back it seems surprising that the third alternative, of placing the cylinders lower and more or less midway between wider spread bogie wheels, was not tried by someone.

The foregoing account of the Austrian and German developments of the Norris 4-4-0—particularly the former—may well be closed by a note of an *inside* cylindered 4-4-0 developed from them. This was a series of 12 engines built in 1852-3 by Cockerill-Seraing for the Austrian Northern (State) Rly. These engines are illustrated by Fig. 35, Cyls. 15x24, Drs. 5/8½. They are of interest because—although the bogie was well rearward of the cylinders and smokebox—they appear to have been the earliest of the classical inside-cylinder 4-4-0 tender engine of Britain and Europe; the earliest of the type in Gt. Britain being T. Wheatley's North British Rly. locomotives of 1871, although there had been 4-4-0 tank engines from 1849. In North America, of course, the type was quite common in the 1850-1870 period, at one time almost rivalling the classic 4-4-0 outside cylinder pattern there. "Piibram" may perhaps be considered as the converging point of the Norris tradition with the 4-4-0 as derived from British practice, and to that extent symbolises the coincidence of design after the parting of British & American practice in 1832 when a bogie was first put to a typical Stephenson engine in the U. S. A.

ALL NORRIS-TYPE LOCOMOTIVES EXPORTED BY NORRIS, AND BUILT IN EUROPE, FOR BELGIUM, FRANCE, ITALY AND SWITZERLAND

The only Norris-built locomotive in Belgium was the "Oliver Evans," a 4-4-0 supplied to the Belgian State line in 1844 having Works No. 181 and it is believed to have had Cyls. 15 in. diameter, Drs. 3/7½; further particulars of this engine are unknown, it was scrapped in 1858.

In a U. S. periodical of 1845 (17) it is stated:—"Railroads of Belgium"—"The government has decided upon the construction of 12 locomotives after the model of those furnished by W. Norris of Philadelphia." This statement evidently must not be taken to mean a decision to obtain 12 Norris-built locomotives as the wording indicates an intention to *construct* the 12 engines. This is particularly mentioned here as the probable explanation of the seemingly inexplicable quantity of locomotives which figure in the list of 1844 already referred to (see Appendix 6) of 19 Norris engines for Belgium, Italy and Wurtemberg.

Although no direct descendants of the Norris prototype in Belgium are known, there exist in later Belgian Rly. documents particulars of a number of 4-4-0 Norris type, but built on the Continent, for the "Sambre-Meuse" and "Belgian State" railways, later Grande Central Belge. As far as the extant information shows all these had all wheels in front of the firebox with the drive on to the rear coupled wheels after the style of Cockerill's engines already referred to.

Some eight or more of these engines were built by the St. Leonard firm and by Cockerill of Seraing for the Etat Belge during 1846-8, whilst the latter firm built at least one in 1849 with four or more repeats during 1852-6 for the Sambre-Meuse Rly. for which the firm of Couillet & Cie. also built six in 1855-6. There were also about four on the Charleroi-Louvain line by Couillet and by Cockerill 1856-9, and five by the former firm for the Morialmé-Chatelineau line during 1855-9. Fig. 36, Cyls. 16x24, Drs. 4/1½, boiler press. 90 lbs., shows one of the Cockerill engines when in service with the Grande Central Belge line about 1870 and may be in its original condition except the chimney. The dimensions of the different batches varied slightly and the boiler mountings of the Couillet engines were more modern in appearance than the Cockerill shown, but it is unnecessary to give a separate diagram of them. There were 18 of these engines at least on the G. C. Belge in 1870 and it would seem these were the remains of a stock of 30 or more. The family likeness of these engines with Cockerill designs for Austria and for Italy—see further on—signify quite a catholic acceptance of their particular features of design of the very similar engines built by the firm Soc. St. Léonard, Liége, no drawing is available.

The only Norris-built locomotive in France, other than the model engine already referred to, was for the Montpellier-Nimes Rly. Resulting from an offer from Norris in December 1842 to supply rolling stock, and very possibly influenced by the gift of the model, an order was given for one engine. This was a 4-2-0 type, being shipped in 1843 and put into service in 1844; the maker's number is not known, but from the date of shipment it would evidently have been around 180. It is stated to have had Cyls. 12x18, Drs. 4/0 and thus was probably a Class "A," although no drawing is known and such cylinder proportions were not a Norris standard.

No 4-4-0 Norris-built engines were supplied to France although the firm tendered in 1845 for the supply of such to the Paris-Lyon Rly., but the offer was not accepted. There were however two 4-2-0 engines from England. These three 4-2-0 engines had a short active career, proving

in no way superior to the usual British and French designs of the period.

In dealing with the Norris locomotives in Italy it is convenient, similarly to the case of Austria, to give a brief résumé of the earliest lines opened; it is somewhat more difficult however because of a number of independent sections of the various lines being opened at different dates—and the existing situation has prevented closer definition. The first railway appears to have been the Naples-Granatello (Portici), five miles, opened in October 1839; next the Milano-Monza section—8 miles—of the Lombardo-Venetian Rly.—referred to in the section dealing with Austria—opened in August 1840 and another section of the same Milan-Venice route between Padova and Marghero opened in December 1842. Then there were the Naples line extension to Caserta in 1843 and to Capua in 1844, the Livorno-Pisa 1844, a further portion of the Milan-Venice route between Padova-Vincenza in 1845 and also the Pisa-Pontedera line in the same year. In January 1846 the Venetian end of the Lombardo-Venetian Rly., including the remarkable long bridge into Venice, was opened, and three sections of other routes including the line from Lucca to Pisa were all opened during the same year.

There were no locomotive-building establishments in Italy comparable to Austria—the first Italian-built locomotive being completed in 1856—and unfortunately very little reliable information seems to have survived respecting the early locomotive stock of these many different lines and this latter difficulty, as will be seen, has left greater uncertainty as to the Norris-built and Norris-type locomotives in Italy than elsewhere.

The first locomotives built in Italy were commenced 1853-4 as in the later year the Verona Railway Workshops, turned out their works Nos. 2 and 3 and at the Ansaldo Workshops at Genoa, the first engine being turned out in 1856; thus for many years all the locomotives were imported. Nevertheless there seems to exist little information about them—at any rate within the knowledge of the author—and a piecing-together produces only a partial picture.

The first locomotive item he has recorded is an order, intended but not confirmed, for two engines which were to have been Stephenson's Nos. 227-8 of 1838-40 for the Milan-Como Rly.; the line itself, similarly to the locomotives, apparently being "not confirmed" at that time.

Particulars of the engines with which a number of the previously mentioned lines were opened is very sparse; the portions of the Lombardo-Venetian Rly. appear to have been worked in the earliest years by 2-2-2 and similar British-style locomotives although built by various British, Austrian, French, Belgian and German firms.

There are only definite particulars now existing of two 4-4-0 Norris-built engines, these being Norris No. 351 and 358 of 1846—built in Philadelphia—and it is fortunately possible to illustrate these engines in Fig. 37. The drawing is obviously made at a date sometime after the original construction of the engines, when they formed part of the stock of the Strade Ferrate Romane. The engines had Cyls. 14x22, Drs. 5 ft. and boiler pressure 85 lbs.; it is to be remarked that the distribution of the wheelbase and most of the details—excluding the boiler, which has a differently built-up firebox indicating a new boiler—are closely identi-

fiable with the Norris-Philadelphia drawing previously mentioned (Fig. 11).

The only other clues to Norris locomotives in Italy are that upon the Naples-Caserta line in 1843 there were one Norris, two Longridge and six Stephenson locomotives, but of the Norris neither the date of construction nor whether it was a 4-2-0 or 4-4-0 type is known. On the Naples-Castellamare line in the same year there were 11 locomotives including 4 by Sharp Bros.; it seems possible there were some Norris engines, but the question is yet unsolved.

From the 1844 list of Norris locomotives to Europe previously mentioned it seems certain there were a number of other Norris locomotives supplied to Italy in the early 1840's and it is possible that the Norris numbers for the two 4-4-0 engines above referred to, viz. 351 and 358 may represent the remains of a set of 8 engines. Apart from this the collation of all the data existing is strongly suggestive that there were some half a dozen further Norris locomotives in Italy probably including some built about 1842-4 of 4-2-0 type. It is realized that this account for Italy is very sketchy and it is hoped someone having access to fuller particulars will be able to fill in some of the missing data.

There were evidently many European-built 4-4-0 Norris-type in Italy, particularly of Cockerill's and following the style of Fig. 36. An excellent illustration appeared in 1939 (R. I. 27) of one of these Cockerill engines in service as late as the present century and affords a striking example at such a late date of a blend of a "Norris" and a "long-boiler."

The author has only traced four Norris-type locomotives in Switzerland, these being two of each of types 4-2-0 and 4-4-0 built by Kessler at Karlsruhe in 1847 for the Swiss Northern Rly. A replica of the former of these was constructed in Switzerland in 1947 for the purpose of taking part in the Swiss Railway Centenary of that year; it is fortunate, therefore, that a photograph of the replica—which is of full size and working trim for drawing a train—is available, and thus Fig. 38 illustrates these engines, also see (R. I. 28). As will be seen they are of "long-boiler" pattern having the driving wheels in front of the firebox; the cylinders were 14½x22 and Drs. 5/0¼ and a wheelbase of 9 ft. 1¾ in.; and they were numbered 1 and 2 on the railway. For the 4-4-0 engines, illustrations are available in (R. I. 29); they were long-boiler pattern, being very similar to the 6 built by the firm the previous year, 1846, for Wurtemberg (see Fig. 32); their numbers were 3 and 4 on the Swiss Northern Rly., Cyls. 14¼x22, Drs. 5/¼.

There were possibly a few other Norris type, by some of the European builders mentioned heretofore who constructed for Austria and Germany, but the writer has been unable to trace them.

NORRIS LOCOMOTIVES EXPORTED TO CANADA, CUBA AND CHILE

There do not appear to have been many Norris engines built for Canada. A 4-2-0 Norris, apparently of Class "B", was supplied to the Champlain & St. Lawrence Rly. Canada during 1837; it was the second

locomotive in Canada, following the "Dorchester" a 0-4-0 "Samson" type by Stephenson 1836 for the same line and being itself followed in 1838 by the well-known three old-fashioned-for-that-date 0-6-0 engines by Hackworth of Shildon, England, for a "coal" line. References have appeared to a second Norris 4-2-0 upon the first-named line, supposed to have been built in 1839, but the Norris list of January 1841 and the report of April 1841 (App. 5 & 6) each show only one locomotive to Canada and the existence of the second has been otherwise disapproved in recent years. The actual engine "Jason C. Pierce" had 10¾x20 in. cylinders and 3/10½ in. drivers, was rebuilt into 4-4-0 type by the Champlain & St. Lawrence R. R., and sold to the St. Lawrence & Industrie Village Rly. in 1850; it was afterwards sold in succession to three or four other small lines and lasted to a little beyond 1886—a total life of 50 years. It seems certain that this was the only Norris of 4-2-0 type to be exported to Canada.

Of the exports to Canada of Norris 4-4-0 type there were eight—it being due to the now well-known Keefer report of 1859-60 that certainty is possible—the Montreal & Champlain R. R. (Champlain Div.) having the "Champlain" of 1847 with 15x22 in. cylinders and 5/0 drivers, and the "Canada" built 1851 having 13x26 in. cylinders and 5/0 drivers; whilst the Great Western Rly. of Canada (5 ft. 6 in. gauge) had six engines in 1851-2, all with 15x22 in. cylinders and 6/0 drivers.

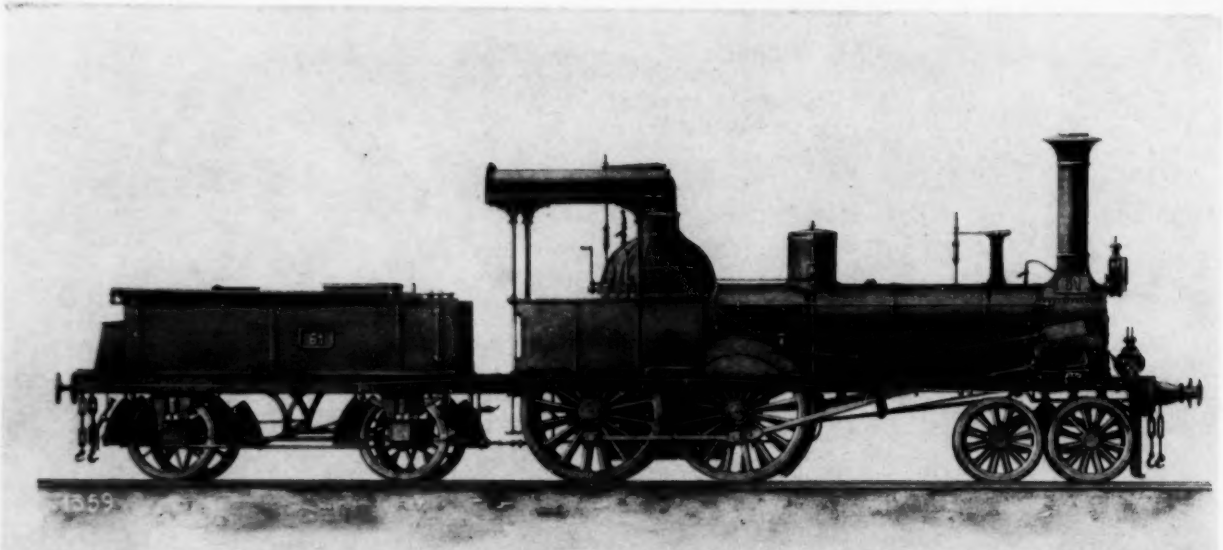
The Norris exports to Cuba possibly commenced as early as the end of 1838—the first Baldwin locomotive to Cuba was shipped in the spring of 1838 and one or more were supplied by Braitwaite & Co. of London before this—and Norris's 1841 Circular (App. 5) tells us that by the end of 1840 they had supplied 5 engines to the Havanna & Guines Rly. and 2 to the Cardenas and Bemba Rly., whilst in April of 1841 (App. 6) there were 6 more yet "to go" to Cuba. The earliest engines supplied were no doubt 4-2-0 type, but the article by H. L. Norris of 1887 (29) referring to the early development of the 4-4-0 type, says a 4-4-0 Norris was built for the Guanabacoa R. R. of Cuba in 1840. Unfortunately no further particulars of these, or other, Norris engines for Cuba have been developed, but the subject is mentioned here in the hope that someone with access to early railway records in that country may be able to trace them.

The Norris firm is also known to have exported locomotives to Chile, although the author's records show no Norris engines on any of those railways, of either 5 ft. 6 in. or Meter gauges, which have ultimately formed the very extensive State lines. There was one Norris however, considered to be the first locomotive in Chile, built in 1850. This was a 4-4-0, named "Copiapó" for the Copiapó Railway—one of the few 4 ft. 8½ gauge lines in Chile,—and it is still preserved in Santiago-de-Chile, where the author saw it some years ago. Fig. 39 shows a full side view of this interesting engine. The cab, of course, is a later addition, but the apron-plate sweeping from the boiler-barrel to the firebox shell—the firebox evidently of the "C" pattern (vide the early U. S. A. section)—is well shown; the slide-bars are of square section but set "square-fashion" and there is a riding cut-off valve. As stated the author knows

of no other Norris in Chile, although there may have been a sister engine on the same railway. Whether there were any other Norris locomotives on other early lines in South America is unknown, and in any case the dates of their manufacture would be outside the scope of this review of the Norris productions in general and exports of locomotives in particular. It may be added, however, that the firm probably supplied a miniature locomotive in 1853 to Japan; vide (47).

This account of the Norris locomotives must not terminate without recording the author's thanks to many friends in the U. S. A.—some of whom may differ from certain of his conclusions—who have assisted in one phase or another of a research of some years, especially to Mr. Thomas Norrell of Maryland, and Mr. Chas. E. Fisher of Massachusetts, as well as to the officers of Messrs. The Baldwin Locomotive Works and of the American Locomotive Company, to the Directors of various Institutions, Museums etc., particularly Mr. C. W. Mitman, of the U. S. National Museum, and, finally, the late Mr. R. V. Wright and Mr. W. A. Lucas of the "Railway Age" and associated publications.

Mention has been made in some places in the foregoing account—whilst in many other parts it is self-evident—of the desirability of additional, or corrective, information. With the Editor's permission it is therefore suggested that Members who may possess authentic particulars of this nature should be kind enough to communicate same to the Editor for the consideration of the Author, who would, in a subsequent Bulletin, summarize and comment upon such fresh evidence.



Strade Ferrate Romane
(Italia)

Costruttore W. Norris - Philadelphia – Anno 1846
Numeri di fabbrica 351 e 358 – Numeri di servizio 61 e 62

Figure 37

Figure 37

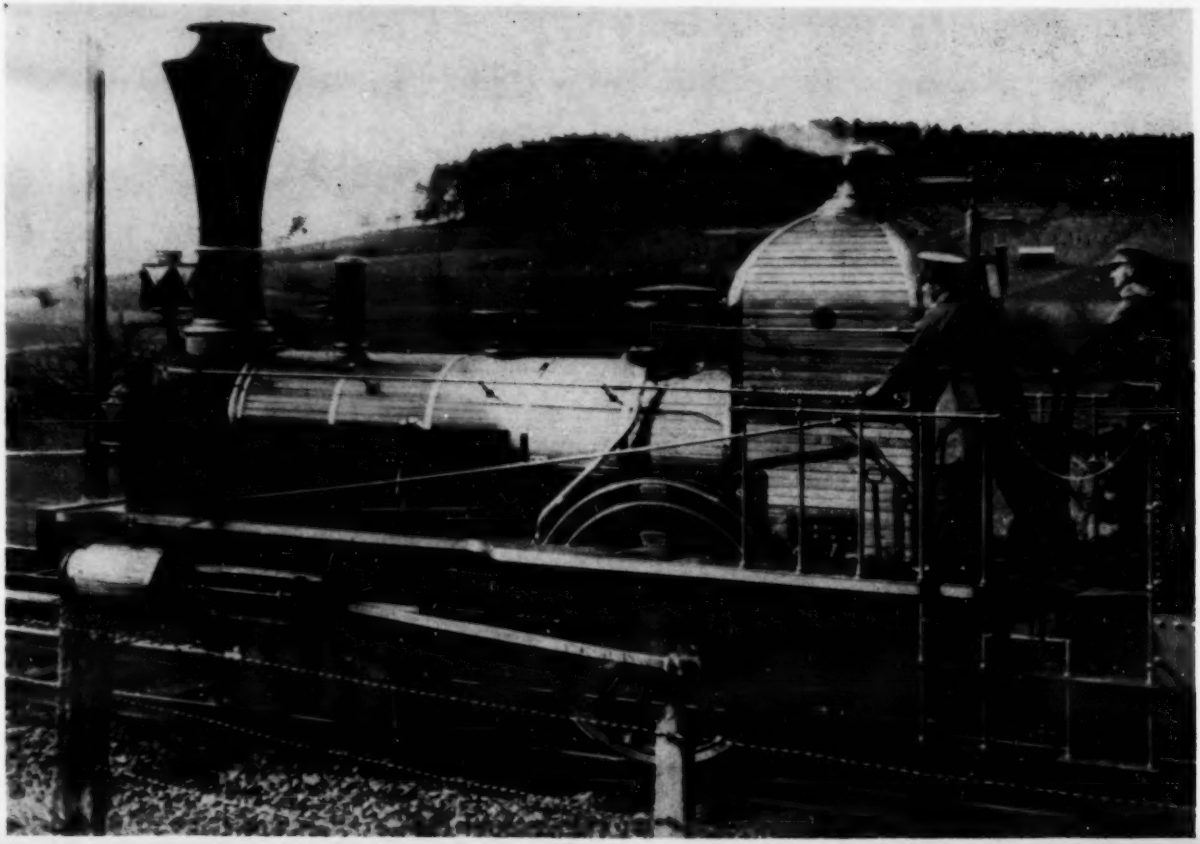


Figure 38

Figure 38

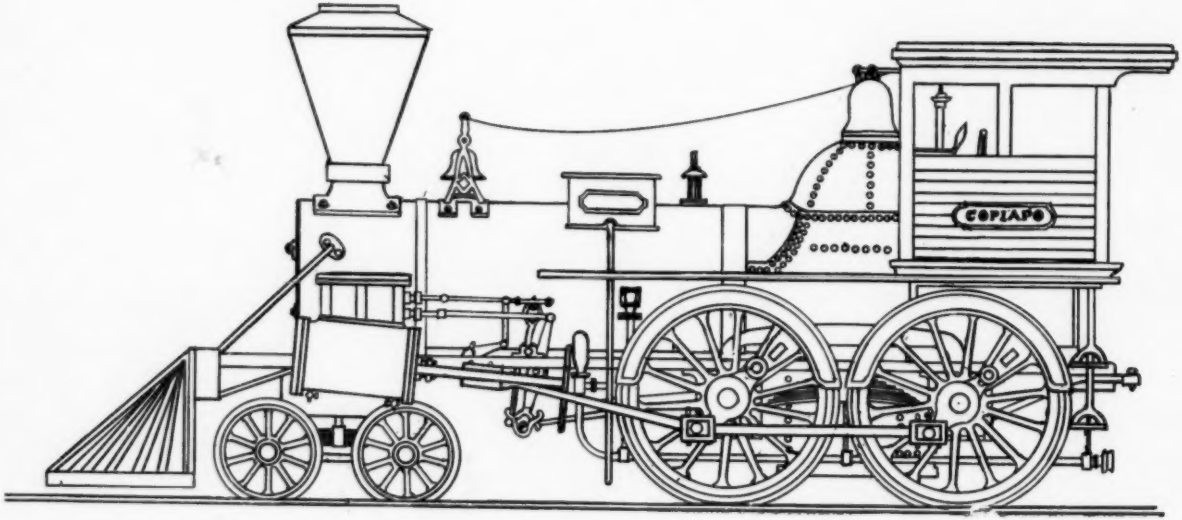


Figure 39

ACKNOWLEDGMENTS

The author wishes to acknowledge the kindness to the following in helping him procure the following illustrations:

Fig. 6 Courtesy of both Mr. Thomas Norrell and the Franklin Institute, both of which furnished illustrations to the editor.
Fig. 9 Courtesy of the Baldwin Locomotive Works.
Fig. 12 Courtesy of W. A. Lucas, Hawthorne, N. J.
Fig. 20 Courtesy of Prof. J. Rihosek, Vienna.
Fig. 21 Courtesy of Prof. J. Rihosek, Vienna.
Fig. 29 Courtesy of U. S. National Museum, Washington, D. C.
Fig. 37 Courtesy of Italian State Railways.
Fig. 38 Courtesy of Swiss Federal Railways.

A good many others are from various publications (including periodicals) especially Helmholtz'—"Die Entwicklung der Lokomotive"—1930.

APPENDIX 1

AUTHORITIES—PUBLISHED BOOKS, ARTICLES, ETC.

(1) "American Railroad Journal"—July 16th, 1836.
(2) "American Railroad Journal"—July 30th, 1836.
(3) "Pennsylvania Inquirer"—October 20th, 1836.
(4) "Locomotive Steam Engine of William Norris, Philadelphia" (Circular) 1838.
(5) Report on Steam Engines, Document No. 21 Treasury Dept. U. S. A. Dec. 1838.
(6) "Treatise on Railways"—P. Lecount—Edinburgh 1839.
(7) Records by Von Gerstner of his visits to American Railroads—dated 1839-40.
(8) "The Steam Engine"—P. R. Hodge. New York 1840.
(9) "Experiments on Locomotive Engines—manufactured by Mr. Norris." Capt. W. S. Moorsom. I. C. E. 1840.
(10) Circular—testimonials etc. by the Norris firm—January 1841.
(11) "Ver. des V. f. Gewerbefleiss," 1842.—Henz.
(12) "Philadelphia Public Ledger"—January 1843.
(13) "American Railroad Journal"—February 1843.
(14) "Description of the American Engine 'Philadelphia'"—G. D. Bishop—I. C. E. 1843.
(15) "Philadelphia Public Ledger"—August 30th, and 31st, 1844.
(16) "Die Baltimore-Ohio Eisenbahn"—C. Chega. 1844.
(17) "American Railroad Journal"—September 1845.
(18) "Economy of Railway Transit"—McConnell's comments. I. M. E. October 1849.
(19) "Norris's Handbook for Locomotive Engineers"—S. Norris. Phil. 1852.
(20) "The Transportation of Passengers & Wares, a Visit to the Norris Locomotive Works," in the "United States Magazine of Science etc." October 1855.
(21) "Railway Machinery"—D. K. Clark—Edinburgh 1855.
(22) "Philadelphia and its Manufacturers"—E. T. Freedley 1858.
(23) "Recent progress in the Locomotive Engine"—Clark & Colburn. London 1860.
(24) "American Locomotives & Rolling Stock"—Z. Colburn, I. C. E. 1869.
(25) "Locomotive Engine & Philadelphia's Share in its Early Improvement"—J. Harrison Junr.—Philadelphia 1871.
(26) "Locomotive Engineering"—Z. Colburn. London 1871.
(27) "American Machinist" 1885—quoted by Sinclair 1907.
(28) "Locomotive Building in America" (History of the Rogers Locomotive Works) M. N. Forney—New York 1886.

(29) "The Norris Locomotive 1836"—Henry L. Norris Junr. in "The Railroad Age Gazette," February 4th, 1887.
(30) "The Locomotive Engine and its Development"—C. E. Stretton. London 1892.
(31) "Locomotive Engineering"—New York April 1896.
(32) "Geschichte d. Eisenbahnen d. Osterr-Ungar Monarchie"—Locomotive Section.—K. Goldsdorf 1898.
(33) "Railroad Gazette"—January 6th, 1899—C. H. Caruthers.
(34) "Growth of the Locomotive"—A. Sinclair—in "Locomotive Engineering" New York 1903-5.
(35) "First Railroad Owned by Government"—C. H. Caruthers in "Railroad Gazette" August 24th, 1906.
(36) "Development of the Locomotive"—A. Sinclair—New York 1907.
(37) "The Norris Locomotive Works"—C. H. Caruthers in "Railroad Age Gazette" August 6th, 13th, & 20th, 1909.
(38) "Extracts from the diaries of David Joy" in "Railway Magazine," London. July 1908.
(39) "An English-built American Engine"—H. T. Walker in "Railway Magazine" London. March 1909.
(40) "Early Motive Power of the B. & O. R.R.—J. Snowden Bell. New York 1912.
(41) "Lokomotiven der K.K. Ost. Staatsb."—H. V. Littrow, in "Zeitschrift des Ost. Ing. u. Archi. Ver." September & October 1914.
(42) "Die Lokomotiven der Norris-bau"—V. Hilscher, in "Die Lokomotive" 1922.
(43) "History of the Baldwin Locomotive Works"—1923 edition.
(44) 'Die Dampflokomotive"—J. Jahn. Berlin 1924.
(45) "Esslingen Locomotiven"—M. Mayer, Berlin 1924.
(46) "Die Lokomotive"—R. Helmholtz, Berlin 1930.
(47) "Railway & Locomotive Hist. Socty." Bulletin No. 32, 1933. P. 70.
(48) "The Engineer".—September 4th, 1936. London. (C. F. Dendy Marshall).
(49) "Norris Brothers, Locomotive Builders".—W. A. Lucas in "Railroadians of America" No. 2. New York 1940.
(50) "The Engineer."—October 3rd, 1941. London. (P. C. Dewhurst).

APPENDIX 2

REFERENCE ILLUSTRATIONS

(R. I. 1) "Development of the Locomotive"—Sinclair 1907—P. 221.
(R. I. 2) "Railroad Gazette"—August 24th, 1906—P. 167.
(R. I. 3) "Baldwin Locomotives"—January 1929—P. 72.
(R. I. 4) "Locomotives & Locomotive Building"—Rogers Works—Forney 1886. P. 12.
(R. I. 5) "Baldwin Locomotives—January 1929—P. 70.
(R. I. 6) "Railroad Gazette"—July 21st, 1899—P. 517.
(R. I. 7) "The Locomotive Engine & Philadelphia's Share . . ." Harrison 1871. Plate.
(R. I. 8) "A Century of Locomotive Building"—Warren (Newcastle, England) 1923. P. 308.
(R. I. 9) "Development of the Locomotive"—Sinclair 1907—P. 361.
(R. I. 10) "Railway & Locomotive Engineering"—July 1905—P. 332.
(R. I. 11) "Baldwin Locomotives"—April 1928—P. 67.
(R. I. 12) "Locomotives & Locomotive Building"—Rogers Works—Forney 1886. P. 7.
(R. I. 13) "The Locomotive & Philadelphia's Share . . ."—Harrison 1871—Plate.
(R. I. 14) "The Locomotive & Philadelphia's Share—." Harrison 1871—Plate.
(R. I. 15) "Norris Locomotive Works"—Railroad Age Gazette—Aug. 13th, 1909—P. 281.
(R. I. 16) "Development of the Locomotive"—Sinclair 1907—P. 288.
(R. I. 17) "Hundert Jahre Deutsche Eisenbahnen"—Berlin 1935—P. 432.
(R. I. 18) "Zeitschrift d. Ost. Ing. u. Archi. Ver. (Littrow). Vienna 1914—P. 662.

(R. I. 19) "Die Lokomotive" (Hilscher) Vienna. Oct. 1922—P. 145.
(R. I. 20) "Die Lokomotive" (Hilscher) Vienna. Oct. 1922—P. 150.
(R. I. 21) "Zeitschrift d. Ost. Ing. u. Archi. Ver. (Littrow). Vienna 1914—P. 672.
(R. I. 22) "Die Entwicklung der Lokomotive"—Helmholtz, Munich 1930—P. 130.
(R. I. 23) "Die Entwicklung der Lokomotive"—Helmholtz. Munich 1930—P. 218.
(R. I. 24) "Die Lokomotive" (Hilscher). Vienna Dec. 1922—P. 181.
(R. I. 25) "Die Lokomotive" (Hilscher). Vienna Dec. 1922—P. 181.
(R. I. 26) "Die Lokomotive" (Hilscher). Vienna Nov. 1922—P. 163.
(R. I. 27) "The Locomotive". London. September 1939—P. 262.
(R. I. 28) "Der Dampfbetrieb der Schweizerischen Eisenbahnen"—Moser. Basle 1938—P. 71.
(R. I. 29) "Der Dampfbetrieb der Schweizerischen Eisenbahnen"—Moser. Basle 1938—PP. 73 & 75.

APPENDIX 3

NORRIS LOCOMOTIVE TRIALS AS REPORTED IN AMERICAN PERIODICALS

(1) "American Railroad Journal" July 16—1836:—Trial of "George Washington" on July 10th. 1836 as described in a "Statement handed us by Mr. W. Norris."
(2) "American Railroad Journal" July 30—1836:—Trial of "George Washington" on July 19th. 1836 with the concurrence of a large body of observers.
(3) "Pennsylvania Inquirer" October 20—1836:—Trial of "Washington County Farmer" on the Tuesday before Oct. 18th. 1836.

Particulars in the above contemporary accounts

	(1)	(2)	(3)
Engine:	*"Geo. Washington"*	*"George Washington"*	*"Washington County Farmer"*
Cyls:—	10¼ x 17⅝	10¼ x 17⅝	10½ x 18
Drg. wheels:	4 ft.	4 ft.	4 ft.
Blr. Press:—	"a fraction under 60 lbs."	"less than 80 lbs."	"under 70 lbs."
Gradient:—	1 in 14.3 (=7%)	1 in 14.3	1 in 14.3
Length of gradient:—	2800 ft.	2800 ft.	2800 ft.
Wt. on Drg. Whls:—	8,700 lbs.	8,700 lbs.	(11,265 lbs.)+
Total Wt. of eng:—	14,930 lbs.	14,930 lbs.	18,170 lbs.
Wt. of train (including the tend.)	19,200 lbs. X	31,270 lbs.	30,116 lbs.
Total Gross Wt.:	34,130 lbs. (=15.24 tons)	46,200 (=20.65 tons)	48,286 (=21.56 tons)
Time taken on gradient:—	2 mins. 1 sec.	2 mins. 24 secs.	3 mins. 15 secs.

X—24 persons on tender and 1 car.
+—calculated at 62% of total weight of 18,170 lbs.

APPENDIX 4

PARTICULARS OF LOCOMOTIVES GIVEN AS THEN BEING BUILT IN NORRIS CIRCULAR DATED JANUARY 1, 1841

Dimensions of 4 classes—on 6 Whls.	A Extra	A	B	C	
Diameter of cylinders	12.5	11.5	10.5	9	incnes
Piston stroke	20	20	18	18	inches
Whole length of boiler	14.5	13	13	12	feet
Length of tubes	9	8	8	7	feet
Number of tubes	97	97	78	58	
Diameter of tubes	2	2	2	2	inches
Fire surface in Firebox	47.4	42.6	35.0	29.3	sq. ft.
Fire surface in Tubes	457	374.5	327	212	sq. ft.
Area of grate	9.5	7.9	7.3	6.4	sq. ft.
Diameter of chimney	13	13	10	10	inches
Height of chimney	7	7	6	6	feet
Diameter of driving wheels	48	48	48	48	inches
Diameter of Truck wheels	30	30	30	30	inches
Weight of locomotive in running order	29,630	24,100	20,615	15,705	Pounds
Ahesion of driving wheels	20,100	16,850	12,781	8,022	Pounds

Note: Three minor items omitted, and areas originally in square inches converted to square feet.

DERIVED PARTICULARS OF FIREBOXES AND BOILER-BARRELS

Class of engine	Pattern of firebox	Diameter of hemispherical top	Length of outer shell at bottom	Diam. of barrel	References
"A Extra"	B	4 ft. 1 in.	4 ft. 1 in.	—	Clark's diagram 1855
"A Extra"	—	—	—	3 ft. 6 in.	Norris tender to Wurtemberg 1844.
"A"	True "Bury"	3 ft. 9 in.	3 ft. 3 in.	3 ft. 4 in.	Copies built by Hick 1840.
"B"	True "Bury"	3 ft. 7 in.	3 ft. 1 in.	3 ft. 0½ in.	"Washington" of Norris circular 1838 & "Norris" drawing published 1887.
"B"	"B"	3 ft. 0½ in.	3 ft. 0½ in.	3 ft. 0½ in.	Pseudo—"Victoria" of 1840.
"C"	Unknown	3 ft. 4½ in.?	2 ft. 11 in.?	?	Calculated from grate area in Norris 1841 Circular.

APPENDIX 5

LOCOMOTIVES LISTED IN NORRIS' ADVERTISING CIRCULAR OF 1841, AS BUILT TO JANUARY 1st, 1841

Company	No. of Locomotives
State of Pennsylvania	15
New Orleans, La., Carrolton R. R.	4
Mexican Gulf R. R., Louisiana	2
Lake Champlain R. R., Canada	1
Philadelphia, Wilmington & Baltimore R. R.	9
Cumberland Valley R. R., Pennsylvania	6
Baltimore & Ohio R. R., Maryland	9
Portsmouth & Roanoke R. R., Virginia	6
Vienna & Trieste R. R., Austria	3
Emperor Ferdinand North R. R., Austria	2
Harrisburgh & Lancaster R. R., Pennsylvania	2
Petersburgh R. R., Virginia	4
Brunswick R. R., Germany	1
Richmond, Fredericksburg & Potomac R. R., Virginia	3
City Point R. R., Virginia	2
Winchester & Potomac R. R., Virginia	1
Clinton & Port Hudson R. R., Louisiana	1
Williamsport & Elmira R. R., Pennsylvania	2
Hudson & Berkshire R. R., New York	5
Havana & Guines R. R., Cuba	5
Cardenas & Bamba R. R., Cuba	2
Monroe R. R., Georgia	1
Wilmington & Raleigh R. R., North Carolina	7
Birmingham & Gloucester R. R., England	15
Berlin & Potsdam R. R., Prussia	2
Franklin R. R., Pennsylvania	1
Norwich & Worcester R. R., Connecticut	4
New York & Harlem R. R., New York	1
Boston & Worcester R. R., Massachusetts	2
Eastern R. R., Massachusetts	2
Raleigh & Gaston R. R., North Carolina	2
New York & Erie R. R., New York	3
Auburn & Rochester R. R., New York	4
La Grange & Memphis R. R., Tennessee	1
Berlin & Frankfort R. R., Prussia	10

This actually totals 138 locomotives whereas the Norris circular states the total to be 135.

APPENDIX 6

AMERICAN R. R. JOURNAL, 1ST. APRIL 1841, SAYS:—

"Mr. Norris has made and sent off 142 engines; and of these there have gone:—

to Germany	2
to Austria	5, & 2 yet to go.
to Prussia	7, & 10 yet to go.
to England	16
to Cuba	7, & 6 yet to go.
to Canada	1

STATISTICS OF "NORRIS" LOCOMOTIVES DELIVERED UP TO 1844

"Exposition de L'Industrie Francaise en 1844"—par J. BURAT
TOME I

Etats-Unis, Canada, Havane	135
Austriche	39
Prusse	23
Angleterre	15
Belgique, Italie, Wurtemberg	19
France	1
TOTAL	232

APPENDIX 7

PHILADELPHIA-BUILT NORRIS LOCOMOTIVES DELIVERED TO THE EUROPEAN CONTINENT—4-2-0 AND 4-4-0 TYPES

1	"Philadelphia"	Gloggnitz	4-2-0	1838	Class B		Built 1837
1	"Columbus"	K. F. Nordbahn	4-2-0	1838	Class B		
1	"Luxemburg"	Gloggnitz	4-2-0	1839(?)	?		
1	"Baltimore"	Brunswick	4-2-0	1839	Class B		Built 1838(?)
2	"America" etc.	Berlin-Potsdam	4-2-0	1839	Class B		Const. #79-80
1	"Baden"	Gloggnitz	4-2-0	1839	Class B		Const. #82
4	"Berlin" etc.	Berlin-Frankfort	4-2-0	1841	Class B		
3	"Oder" etc.	Berlin-Stettin	4-2-0	1841	Class B		One lost at sea
3	"New York" etc.	K. F. Nordbahn	4-2-0	1841	Class A		12½" cyl.
3	"Brandenburg" etc.	Berlin-Frankfort	4-2-0	1842	Class B		
7	"Concordia" etc.	Berlin-Frankfort	4-2-0	1842	Class A	Extra	Class A(?)
1	"Spree"	Berlin-Frankfort	4-2-0	1843	Class A	Extra	Class A(?)
1	"Rubezahl"	Breslau-Schweidnitz	4-2-0	1843	Class A		
4	"Budweais" etc.	Nor. Staatsbahn-Austria	4-2-0	1844	Class A	Extra	Built 1843(?)
1	?	Montpellier-Nimes-France	4-2-0	1844	Class A		Built 1843
1	"Oliver Evans"	Belgian State	4-4-0	1844	?		Const. #181
3	"Donau" etc.	Wurtemberg State	4-4-0	1845	Not L-Boiler		
2	"Berg" etc.	Berg-Mark	4-4-0	1846	?		Const. #215-6
2	Nos. 15 & 16	Hannover State	4-4-0	1846(?)	?		
4	"Columbus" etc.	Baden State	4-4-0	1846	Long Boiler		Const. #252-3
2	"Papin" etc.	Hessian Northern	4-4-0	1846	?		Const. #291-2
10	"Gleichenberg" etc.	Sud. Staatsbahn-Austria	4-4-0	1846	Long Boiler		Const. #310-9
12	"Ocean" etc.	Sud. Staatsbahn-Austria	4-4-0	1846	Long Boiler		Const. #331-42
2	"Nader" etc.	Hungarian State	4-4-0	1846	Long Boiler		Const. #343-4
2	(Later Nos. 61-62)	Italy	4-4-0	1846	Not L-Boiler		Const. #351 & 8
2	"Hirsch" etc.	Hessian Northern	4-4-0	1847-8	?		Const. #359-60

Notes: Dates generally show the year the locomotive commenced service. Construction was sometimes the year previous. There may be eight instead of the two 4-4-0's for Italy and there were probably others built earlier, probably of the 4-2-0 type for Italy.

Name of railroad.	Name of locomotive.	Power of engine, in horses.	High or low pressure.	When constructed.	By whom constructed.	How long in use.	Remarks.
Beaver Meadow	Beaver	26	-	1837	Garrett & Eastwick, Philad.	1 year.	
	S. D. Ingham	18	-	1836	Do. do.	2 "	
	Elias Eley	18	-	1836	Do. do.	2½ "	
	Quakake	18	-	1836	Do. do.	2 "	
	Nonpareil	26	-	1838	Do. do.	3 months.	
Allegheny Portage,* (from Hollidaysburg to Johnstown.)	Boston	15	High	1832	Bolton and Co., Boston	4 years	These engines have *inside* connexions, and *short* pitmans, producing much friction. *Iron truck frames—an improvement.*
	Mountaineer	15	do.	1834	McClung, Wade & Co., Pittsb'g	4 "	
	Delaware	15	do.	1833	E. A. Young, Newcastle, Eng.	4 "	
	Alleghany	17	do.	1834	Do. do.	3 "	
	Pittsburg	15	do.	1834	McClung, Wade, & Co., Pittsb'g.	3 "	
	Backwoodsman	17	do.	1836	Do. do.	2 "	
	Conemaugh	17	do.	1836	Do. do.	2 "	
	Benj. Franklin	15	do.	1835	Long and Norris, Philadelphia	3 "	
	Robert Morris	15	do.	1836	William Norris, Philadelphia	2½ "	
	Geo. Washington	20	do.	1836	Do. do.	2½ "	
	James Madison	20	do.	1836	Do. do.	2 "	
	Bush Hill	25	do.	1837	Do. do.	1 y'r & 9 ms.	These engines require not more than half the fuel and oil required by other engines performing the same amount of work; easily managed, and requiring few repairs; performances unequalled on this road. Improvements are *outside* connexions, *long* pitman, with wrist *outside* of drivers.
	Independence	25	do.	1837	Do. do.	Do.	
	Constitution	25	do.	1837	Do. do.	Do.	
	United States	25	do.	1837	Do. do.	Do.	
	Lafayette	20	do.	1837	Do. do.	Do.	
	Comet	15	do.	1837	E. A. Young, Newcastle, Eng.	1 year	*Inside* connexions: well constructed; performances tolerable.

* On the Allegheny Portage railroad there are 20 stationary engines, (all high pressure,) of which 9 are of 30-horse power each, equal to 270; 6 of 25-horse power each, equal to 150; 4 of 20-horse power each, equal to 80; and 1 of 40-horse power; making a total of 500-horse power—one-half of which is in constant use.

COLLECTOR'S OFFICE. *Philadelphia, November* 15, 1838.

JOHN KERN, *Deputy Collector.*

APPENDIX 9

From Mr. Robert R. Brown, our Canadian Representative, we received the following relative to the Norris locomotives that were delivered to Canada:

Champlain & St. Lawrence Railroad

Jason C. Pierce 4-2-0 10¾x20" 56½" 1837 Norris

The second locomotive in Canada; converted to 4-4-0 type probably in 1847 or 1848; sold in 1850 to the St. Lawrence & Industrie Village Railway; later altered to 4-4-0—12x18" 48"; in 1881 became Quebec, Montreal, Ottawa & Occidental Railway #33; in 1882 became North Shore Railway #1; in 1885 became Canadian Pacific Railway #197; in 1889 sold to L'Assomption Railway; destroyed shortly after. The original name, Jason C. Pierce, was retained at least until 1881 but, after 1850 it was better known as the "Pacaud."

Montreal & Lachine Railroad

Lachine 4-4-0 15x22" 60" 1847 Norris

Came to Montreal by barge via Lake Champlain and the barge was the first American vessel to visit Montreal harbour. In 1849, the Lachine was sold to the Champlain & St. Lawrence Railroad and renamed "Champlain", #7. Scrapped about 1873.

Champlain & St. Lawrence Railroad

Canada #6 4-4-0 13x20" 60" 1851 Norris

Scrapped by the Grand Trunk Railway about 1873.

Great Western Railway—Broad Gauge 5' 6" 4-4-0 16x24" 72" 1853 Norris

1853	1862		
35	17	Venus	All converted to standard gauge in 1872-3 and scrapped between 1875 and 1880.
36	18	Vesta	
37	19	Minerva	
38	20	Jupiter	
39	21	Mercury	
40	22	Mars